

## SHIPYARD LAYOUT

by

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for the Degree of  
Master of Science  
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Signature of Authors

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Signature of Professor in Charge  
of Research

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Signature of Chairman of  
Department Committee on  
Graduate Students

.....

Cambridge, Mass.  
3 June 1946

Professor B. W. Swett  
Secretary of the Faculty  
Mass. Institute of Technology  
Cambridge, Mass.

Dear Sir:

In accordance with the requirement for the  
Degree of Master of Science in Naval Construction  
and Engineering, we submit herewith a thesis entitled  
SHIPYARD LAYOUT.

Respectfully,

*Lin Chen-Ming*  
.....

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## Summary

The object of this thesis was to investigate the conditions, methods and procedures in laying out an efficient shipyard and one which would be best suited to meet the huge postwar reconstruction and repair program of the Chinese Navy.

The investigation was carefully made

- (1) By visiting some of the leading shipyards along the Atlantic Coast, both naval and commercial, such as Boston Navy Yards at Boston and South Boston, Massachusetts, Bethlehem Steel Company Shipyards both at Quincy and Hingham, Massachusetts, the Bath Iron Works at Bath, Maine, and the Philadelphia Navy Yard at Philadelphia, Pennsylvania, and Sun Shipbuilding and Drydock Company at Chester, Pennsylvania;
- (2) By studying the historical and technical background;
- (3) By discussing with those people who have been working in the yards for many years;
- (4) By referring to the up-to-date transactions, papers, and magazines.

The principal contents of this investigation are as follows:

- (1) The historical background of the Chinese Navy.
- (2) How many ships will be built and what type of yard is best suited?

- (3) How to chose the best location for a Navy Yard?
- (4) How to manage and organize a modern shipyard and what kind of management and organization is best suited for China.
- (5) How to arrange a shipyard in the most efficient way and how are the important shops related to each other.
- (6) The detail layout of important shops and their characteristics.
- (7) How to train the workers to meet the future needs of the Chinese Navy.
- (8) How to estimate the cost.

By following the above procedure and methods, the authors believe that a navy yard which is best suited for post-war China can be built up economically and efficiently.

## INTRODUCTION

The Historical Background of Chinese Shipbuilding

Just when China started to have vessels we do not exactly know. But its first appearance in the literature could be found in "Yi-Ching" which may be translated as "The Book of Changes," one of Confucius' Five Classics. It states that "Lord Foo-Hsee scraped trunks of trees for canoes; and burned the branches of trees to form oars." Lord Foo-Hsee was the second lord in Chinese history; the time corresponds to about 2800 B.C. He also was the wise man who taught people to build houses to live in instead of living in the trees and caves.

Hsia was chosen to be Sung's successor by Lord Sung himself on the account of his great achievement in flood control, formerly floods had caused the loss of thousands and thousands of lives, and millions of dollars worth of goods. Even Hsia's father had lost his life in a flood. In 2205 to 2210 B.C. we are told, Hsia traveled thousands of miles in vessels equipped with sails and rudders.

Between 557 and 589 B.C. Lu-Pan a wise carpenter invented a propelling scull which still is used many junks. This means of propulsive is called Lu after the inventor.

Emperor Yang of the Sui Dynasty went to visit his home town in Kaingsu province from Peiping a few years

after he was throned; and this happy journey was made in a fancy dragon boat especially provided for this trip which sailed on the Grand Canal. Both the Canal and the dragon boat were considered the greatest achievement in Chinese history up to that time. The canal improved the water transportation which then became the most comfortable way to travel. Travel by boat on the part of the Emperor gave great prestige to this means of transportation and encouraged the shipbuilding throughout the nation.

Emperor Ming of the Tang Dynasty should have the credit for introducing ships for military use in Chinese history. He let his men build up a fleet of warships and attempted to cross the East China Sea to conquer Japan. This fleet was dispressed by typhoon, however.

If the credit for warship development belongs to Emperor Ming, then the credit for merchant ships' development should certainly belong to Emperor Tai-Chun of Ming Dynasty (1386 A.D.). His able minister Che'n-Ho operated a fleet of merchant ships, consisting of sixty-two huge junks. Each of these vessels was 440 feet long and 180 feet wide. These ships or junks were built at the same time and were used over a long period of time. They made many voyages including the South Pacific Islands. This period may be considered the critical period of Chinese shipbuilding.

Steel vessels were first introduced into China in the very early stage of Ching Dynasty. In that time China was the principal sea power in the Far East. Unfortunately she was later defeated by the Japanese Navy in the first Sino-Japanese War. The plan of reconstruction of a new Navy was rejected by the Empress Dowager and never again it had been brought up. The policy of the Ching Dynasty encouraged the people to make themselves proficient in literature, philosophy or anything connected with writing which gave them the good name "scholar" and caused them to look down on the people who actually worked and to call them laborers. As a result of this policy the Chinese became weaker and weaker as far as industrial abilities is concerned. Unfortunately this occurred just in time to be a drawback, it being a period during which other parts of the world were making a remarkable progress in industry. Steam power has made possible the impossible things of the past, and steel and other metals has given the new life to industries, especially ship construction. Thus Chinese industry was left far behind. Due to the loss of the "Opium War" to the British, many unequal treaties were forced upon the Chinese people. Free development of any kind of industry seemed to be impossible and shipbuilding practically ceased.

Condition of Navy Ships before the Outbreak of Current World War

When World War II started our Navy had only about 50 gun-boats with total displacement of about 30,000 tons ~~(1)~~.

Condition of Merchant Vessels before the Outbreak of the Current World War

At that moment we had 3,353 ships with total displacement of 607,901 tons ~~(2)~~.

Condition of Shipyards before the Outbreak of the Current World War

I. Government Owned:

- (a) Foochow, Mamoi Navy repair yard. Established in 1855, consists of 13 shops, and one 180 feet graving drydock. But no major improvements since.
- (b) Canton, Wanpoo Yard. An old British abandoned yard; can only be used as a repair yard.
- (c) Tsingtao Navy repair yard. Established by Germany before the First World War, much better than Wanpoo yard, consists one graving dry dock. But most of the machines were old and inefficient and have a capacity of 10,000 tons per year.
- (d) Shanghai Kaing-nan Dock and Eng. Works: The biggest yard of the Chinese Navy (in fact

the largest yard in China). Established in 1905 it consists of three graving dry docks; ranges from 600 feet to 540 feet. Had an average capacity of 50,000 tons per year, and maximum capacity of 150,000 tons per year. And her workers are considered as the most skillful workers in the country in this trade.

- (e) The others: Consists of Amoy Navy repair yard, Taku yard, and the inland yards such as Harbin Iron Works, Wuchang Iron Works, and Shanghai Inland steamer repair shop. All of these were not able to build new ships. Engine repair was restricted to reciprocating engines.

## II. The Private Yards:

- (a) Shanghai Chung-Hwa yard
- (b) Shanghai Ho-Hsin Iron Works
- (c) Shanghai Kung-Mao yard
- (d) Shanghai Chiu-Hsin yard
- (e) Shanghai Hunt-Chang yard
- (f) Shanghai San-Pai yard
- (g) Shanghai Yuan-Dar Iron Works
- (h) Wuchang Kaing-Hen yard
- (i) Yichang Hun-Chung Iron Works
- (j) Chungking Min-sun Iron Works

(k) Hongkong Tung-Yi-Hsing Iron Works

(l) Hongkong Chen-Chi Iron Works

(m) Hongkong Hsieh-Tung Iron Works

All above yards are not capable of constructing a new ship over 3,000 tons. Only the Shanghai and Hongkong yards can build seagoing vessels.

#### Condition of Shipping before the Outbreak of the Current World War

The shipping report made by the custom house in 1936 stated that the total shipping were 145,010,018 tons, and only 44,171,645 tons out of the total 145,010,018 tons was carried by our own ships.

#### Condition of Navy Ships during the War

All seagoing gunboats were sunk by enemy air attack at beginning of the war. Only a few shallow water river gunboats were brought to upper Yantze River, with two river mine sweepers which served as transport ships during the later stages of the war. Two U.S. gunboats; two British gunboats and one French gunboat were received by the Chinese Navy when new treaties between China and these three countries were signed after Pearl Harbor.

#### Condition of Merchant Vessels during the War

Most of the seagoing vessels which could not be brought up to the upper Yangtze were used for the purpose of blockade. The remaining tonnage was only



100,000 tons. Even this small amount of tonnage was subject to bomb attack. Times and again ships were damaged and repaired, through out the war. In spite of all difficulties 14 new ships were built in Chungking Min Sun Iron Works during the war.

#### Condition of Shipyards during the War

The Chungking Min-Sun Iron Works is the only yard left. This and the refugee yard San-Pai from Shanghai were the busy yards throughout the war. Min-Sun Iron Work is probably the only yard in the world who has such huge machine shop in a cave, so that it can keep working during air raids. This made possible the building of 14 new ships during the war.

#### Condition of Shipping during the War

Coastal shipping was cut to nothing after the fall of Canton. River shipping was limited to carrying out military duties and refugee transportation only. Commercial shipping was once again carried on by Junks.

#### Condition of Naval Vessels in Present Time

Some Japanese Naval vessels will probably be transferred to the Chinese Navy but definite information on this point is not available. Also some U.S. and British surplus may be given to the Chinese Navy, but definite information is also lacking on number and types.

Condition of Merchant Ships in the Present Time

It is believed that 100,000 tons of ship will be added to the tonnage which remained at the end of the war, by taking over the Japanese merchant vessels and buying U.S. surplus ships.

The Shipping Condition at the Present Time

As reported by the Times Weekly Newsmagazine, March 25th, 1946: "River and coastal shipping is down to 100,000 tons from the 1,000,000 tons. But it does not indicate that there is no demand of waterway transportations but it merely meant there is not enough ships to fulfill that demand.

Looking Forward to the Near Future

In the near future China must have enough ships to satisfy her requirements. This will mean that we should have at least 1,800,000 tons of merchant ships on the assumption that the sea trade will still remain the same as just before the war. At that time sea-borne commerce had already shrunk due to the fact that everyone was expecting this was from the condition of Sino-Japanese relations during the ten-year period from 1926 to 1936.

As to the warships, at least all the warships which we now have and/or are going to have should be kept in good condition, and a great many more should be added to constitute a Navy adequate for China's needs.

### Condition of Shipyards at the Present Time

As far as authors know the Kaing-Nan Dock and Engine Works in Shanghai have been restored and were put into operation right after the Chinese troops entered Shanghai. The yard, however, suffered considerable damage in buildings and equipment from both artillery and bombers. Some private yards are undergoing reorganization and will probably begin operations soon. But even the facilities to fulfill the demand for ships will materially exceed those existing. The needs of ships, which were reported to the People's Political Council by the National Reconstruction Committee two years ago, were that during the first five years after the war in order to fulfill the requirements for the National Reconstruction Program China needs 309 new seagoing vessels and 2,939 new river boats. The latter figure included tugs and ferry boats for some bigger cities. This report suggested the following program.

First year	50,000 tons
Second year	135,000 tons
Third year	300,000 tons
Fourth year	450,000 tons
Fifth year	650,000 tons

Along with this new shipbuilding program a great many yards will have to devote their full capacities

to repair and salvage work. A number of workers will have to be trained to supply all these needs in the various yards. It is therefore apparent that a new yard will have to be established to accomplish all the work planned.

### Capacity and Type

The capacity of the yard depends on the demand. From the foregoing analysis we assume that three-fifths of the new work will be accomplished by the existing yards in the country. Then this new yard should have the capacity, in the first year, of 20,000 tons of merchant plus about 5,000 tons of Naval vessels, as well as some repair work, with the object of attaining a normal capacity in the long run of 250,000 tons per year and provisions for even further expansion.

### Types of Ships To Be Built in the New Yard

The types of ships to be built in this new yard will be merchant ships as well as war ships, as stated above, for China now faces a very serious problem of getting merchant ships for immediate use in the National Reconstruction Program. Thousands of refugees are awaiting ships to go home and tons of foods are waiting to be transported into the war torn provinces and cities. Furthermore, since the equipment to be used in this yard will be new to the workers who are going to be hired, and since merchant ship work is comparatively less expensive, it will be better to start on merchant ship construction. More important experience in this type of work will give the yard something to fall back upon during peace time when warship construction is not very active.

Type of Yard

Type of the yard depends not only on what types of ships are going to be built therein but also on the methods to be used in construction, and on the policy of the yard.

Welding will not be used in the important parts of the ship in the very beginning, due to two major reasons; first, there are no expert workers in this trade now available; second, no positive means, at the present time, can be used to inspect the work as far as China is concerned. It is intended to use welding in increasing amounts year after year as the workers can be proved capable of fulfilling the requirement in this type of work by the experience they had gotten from working on nonessential parts. A quick and cheap way to inspect the work can be found.

Due to the foregoing reason large preassembling work will not be used in this yard from the time being. Large preassembling does not save any time and money; all it does is to reduce time on the shipways. As this is not necessary in peace time, this yard will not adopt large preassembling work. Provision, however, should be made so that it could be converted into that type of yard with practically no loss of time if another war is inevitable.

A repair yard will be attached to the yard for the repair work. The advantage of including a repair yard is that when a new shipbuilding program is on the downswing, which is inevitable since the ships are needed only if business in general is good, a yard which has repair facilities will be much better off than the yard which does not have such facilities. By that time those ships which have been in service for a certain period will come in for painting, cleaning, repairing, and so forth. Even when the construction of new ships is still at its peak, the new work would not be affected much by shifting some of the workers to the repair work, which is usually more urgent than the new work. The workmen under this arrangement will work faster than those who are specially hired for the repair job, because they need not have any fear of being laid off after the work has been completed. Consequently, a repair work yard is worth having both as a financial saving and as a way of keeping the workers in the yard. Otherwise, they may go to other trades or the community may be disrupted by the wandering people who have been laid off by the yard. Thus the repair yard will help the yard to iron out the peak and serve as an accumulator to keep the yard in smooth operation.

## Discussion of Dry Dock

### Uses of Dry Docks:

- (a) Docking is necessary when a ship has to have the underwater part of its shell cleaned, painted, inspected, repaired or reconverted. In all these jobs the yard which has dry dock facilities will have a great advantage over those not similarly equipped.
- (b) Sometimes it is desirable to build ships in the dry dock instead of on the shipways if the dry dock is not otherwise used. In the first place, the ship can be built on an even keel. It is practical to hire less expert shipwrights or shipfitters for such work, because their labor is cheaper. When a ship is built on an inclined shipway, if the shipwrights or fitters are not experts, they might erect the fittings perpendicular to the water level instead of perpendicular to the ship herself, for they might forget to correct the line derived from the plumb line, to the declivity of the ways or keel blocks. When a ship is built in the dock which has a level floor, an error of this sort will not occur. Second, the risk of launching will be avoided since no launching will be necessary. This is very important in a yard which



has a narrow waterway in front of the ship building way and a longer ship is to be launched. Also the launching calculation can be omitted, which will be good news to the planning department and designing office.

- (c) Dry docks such as marine railways and lift type docks sometimes are used as the launching ways. When small vessels are built at the side of the marine railway or lift type dock railway, they may be moved to the lift type dock for launching.
- (d) According to the custom of shipbuilding when a ship is completed she has to be docked once before she is delivered. So it might just as well be built in the dock.

#### Types of Dry Docks

- (a) Graving Dry Dock:--This is a dock formed by excavating a piece of land into the shape of a basin from which the water can be kept out by a caisson, so that the ship can be brought in and docked for repairs, cleaning, etc. The side of the dock is usually reinforced by a stone wall or wood or steel piles. The advantages of this type of dock are:

- (1) Space saving:--The dock is dug in the ground so it requires just the space for docking ships. While in the case of the floating dock, more space is required for its wing tanks.
- (2) Ease in handling materials:--Since the dock is part of the yard, the materials can be brought right to the dock by the use of locomotive cars, or cranes without difficulty.
- (3) Proximity to the shops:--As stated before, a graving dry dock is a basin dug in the ground so it can be as near the shops of the yard as desired.
- (4) Very low <sup>MAINTENANCE</sup> costs:--The graving dry docks are made solely of stone and steel coated with corrosion resistant materials, both of which can last for a hundred odd years, as has been proved by various yards in the world. For instance, the Boston Navy Yard and the Norfolk Navy Yard own graving dry docks which are over a hundred years old and yet they are as efficient as when they were new. The

only part that may need replacing is the caision. This will be a small expense compared to the upkeep of other types of docks.

(5) Less pumping when a large ship is docked:--

It is obvious that the larger the ship the greater the water displacement in the dock, so less water will be left in the dock after the caision is closed. Hence less pumping work has to be done.

(6) Fewer accidents:--The more moving parts there are in an engine the more trouble they will cause. This is also true in docks. In the graving dry dock the only moving part is the caision and it remains stationary when the docking is taking place. So the graving type dry dock gives rise to fewer accidents than other types of docks.

(7) Use as building slips:--Dry dock is the ideal place for new construction as discussed before, but it is only practicable in graving dry docks. A floating dry dock, for instance,

will trim and roll when weights are being moved and this will interfere with construction. And the marine railway has a slope, while the lift type and camel type are out of the question.

The disadvantages of graving dry docks are:

- (1) High first cost:--A terrific amount of soil will have to be excavated and the large stone wall and floor will require a tremendous amount of work as compared to the other types.
- (2) Unmovable:--This is comparatively undesirable characteristic of the graving dry dock, because sometimes a movable dry dock is very desirable especially in salvage work where the damaged ship is hard to move.
- (3) Dependent on the tide:--It is also undesirable when ships are in a hurry that the water is not deep enough for them to dock or move out. But it would not be too bad if they were not in a hurry. Sometimes we can take advantage of reduced pump work.

It will not be too greatly affected if the tide does not change much.

(b) Floating Dry Docks:--These are the docks which lift a ship up by their own buoyancy. It is actually like a potoon but can be sunk by filling it with water or floated by pumping out the water. Here only the sectional self-docking type will be discussed since in the opinion of the writers, it is the best of all the types of floating dry docks. It can dock in sections or be divided into several docks when necessary.

The advantages of floating dry docks are:

(1) Lower first cost:--Since the floating dry dock has an almost rectangular shape, it is simpler to then construct ships. So the first cost of the floating dock is less than that of the graving dry dock.

(2) Movability is the most desirable characteristic in a dock, and in this the floating dry dock is superior to another types of dry docks. As pointed out before, when a large ship is damaged it is more convenient to move a dry dock to her rather than to bring her to the dry dock.

- (3) No waiting for tide:--Here it is also superior to the gravity dry dock, since the dry dock herself can be regulated with respect to the water level so the tide level would not affect her operation at all except when the water falls so far that even the floating dry dock herself is grounded. As we said before this would not be too important in a port where the tide does not change the water level much.
- (4) Less pumping for small ship:--It is just opposite to the graving dry dock. The floating dry docks ships by gaining buoyancy herself to compensate the weight of the ship which she is going to dock. So the smaller the ship the less water will have to be pumped away from the dry dock herself.
- (5) An easy way to check the stress of a ship by a sectional type floating dry dock.--The support of the respective parts can be raised and lowered just by filling in or pumping out water of the respective sections.

The disadvantages of floating dry docks are:

- (1) Higher upkeep:--Floating dry docks, like ships, have to be docked from time to time to have their underwater portion checked. Due to the frequent changes from dry to wet or from wet to dry, they rust faster than ships. And place should be provided for mooring them.
- (2) Difficulty in handling materials:--This is because the dock herself rests on a soft foundation (water). As stated before, when heavy weights are moved the dock will list or trim and so disrupt the work. Furthermore, the dry dock is separated from the land. It will not be possible to move the material from shops or other parts of the yard by railroad cars or Gantry cranes. It costs more money for handling materials.
- (3) Farther from shops:--This disadvantage is obvious, because the dock is separated from the shore.

(c) Marine railways:--From the name we can see that this type of dry dock must consist of rails. The ships are pulled to shore by chains with the initial trim by stern.

The advantages of the railway type dry dock are:

- (1) Cheapest first cost:--The construction of this type of dock is simple requiring only rails, chains, the power to pull the ships up to the rails, and a sound foundation, so its first cost is very cheap.
- (2) Quickest operation:--When the ship is pulled up all work is done. And no water needs to be pumped.
- (3) Parts can be moved:--Since it is just like a railway, its parts can be moved and replaced easily.

The disadvantages of the railway type dock are:

- (1) Too much space necessary for property line:--The pulling power has to be at one end of the dock, the windlass or whatever it is, will occupy a space at the end. With the same length of dock this type will require a longer space.



(2) Farther from the shops:--This is because the longer parts at the ends take up space and the materials have a longer way to go from the shops or store houses.

(3) Difficulty in handling materials:--The slope of the rail and ship is higher than when she is docked in another type of dry dock (other than the lift type dry dock) so it requires higher or larger cranes to handle materials.

(4) More accidents:--When a ship is pulled up, if unbalance occurs the ship might fall on its side, because there is no rigid support on either side. The failing of a chain or some other part of the pulling mechanism may also be expected.

(5) Mechanical features limit the size:-- Since the ship has to be pulled up by either mechanical power or electrical power, it will require a huge mechanism. In the light of present knowledge its size is still limited. It is still impractical to dock too large a ship in this type of dry dock.

- (6) Waiting for tide:--The ship has to be pulled up to the rail, so the minimum elevation of the ship when the pulling begins should be a little higher than the ends of the rails. So waiting for the tide is inevitable. This is not too great a disadvantage at ports where tides do not change much. But in a place like Chungking with a difference in level of some 90 feet (between winter and summer) will be a very important factor in deciding whether or not to have a dry dock of this kind.
- (7) Ships docked with initial trim:--This is important when a ship comes into the yard with an initial trim by stem due to damage and heavy weights have to be added to change the trim from by stem to by stern. This is undesirable as it may induce excessive stress to the ship which has already been strained damage.
- (8) Not level required trained shipfitters:--Same as at the sloped shipways as discussed before.

## (d) Lift type dry docks and Camel type dry docks:--

These are all small and expensive so we are not going to discuss them in detail. Only their advantages and disadvantages are listed here. The advantages of the lift type dry dock are:

- (1) No waiting for tide
- (2) Requires little space
- (3) Ease in handling materials
- (4) Close to shops
- (5) Ships docked on level

The disadvantages of the lift type dry docks are:

- (1) Capacity limited to small ships
- (2) High first cost
- (3) High upkeep

The advantages of the camel type dry dock are:

- (1) Can be used in shallow draft
- (2) Can be readily moved about
- (3) Other advantages, like those of the floating dry dock

The disadvantages of the camel type dry docks are:

- (1) Inefficient as floating dry docks
- (2) Large stress in pontoon due to large wings
- (3) Made to specific dimension

### Shipbuilding Basin

The shipbuilding basin is an interesting type of building slip, when a shallow dry dock has been constructed with a depth over the blocks at mean high water of 20 feet. The dock has essentially the same dimensions as the largest ship which is to be built in the Yard, and in the details of construction resembles other large graving dry docks except that the draught is very much reduced. The caisson will be of the usual type; provision will be made for pumping out the dock. With this arrangement, the weight handling facilities could be of any type that might be selected for the normal type of ship. The advantages in this construction are, first, of course, the elimination of the risk and expense of launching, and second, the facilitating of the erection, due to building on an even keel, and the elimination of the difficulties incident to delivering men and materials at the height of a vessel when built on an inclination. In addition to being on an even keel, the vessel will be very much lower (approximately 50 feet), and the height of the weight handling cranes can be correspondingly reduced. If the condition at the yard at this time makes it desirable, the vessel can be carried to any degree of completion prior to launching, with the only limitation that the draught cannot exceed the depth of the water over the blocks. A building slip of this type has a further value, in that considerable

periods of time may elapse during which building work is not carried on, and the slip will then be available for use as a dry dock or a wet slip for small vessels.

#### Choice of Type of Yard

As discussed before this yard will not use welding at the beginning or large preassembling except in case of emergency. The shipbuilding basin will be adopted because the selected site is suitable for shipbuilding basin. And as stated before, it is profitable to adopt it whenever possible.

One 2000 ton capacity sectional self-docking type floating dry dock is expected to be built in this yard. This will be more fully dealt with in the discussion of the general layout of the yard.

Two marine railway type dry docks each having a capacity of 1000 tons seem to be profitable for this yard.

One 1000 feet dry dock of the graving type will be added to this yard to make repair work on large ships possible.

MANAGEMENT AND ORGANIZATION

During the war, time was the very essence of all contracts, with expense a less than secondary consideration. With conditions reversed and a reasonable time to adjust themselves on a strictly economical basis, shipbuilders will continue in business only so long as they pay attention to factors under their control. A cursory analysis of the situation indicates that the factors under direct control of the shipbuilders are management, organization, and, to a greater or lesser extent, men.

The most successful industry, not only during the war but also in peace time, is very largely a matter of management and organization. In modern thought, the former is considered an art and the latter a science. Science above all things demands exactness, and the reasoning back of referring to organization as a science is that it is, or should be, based on certain facts determined entirely by the nature of an industry and the various operating functions by which it is controlled. That management may justly be termed an art must be admitted when one considers the varying degrees of success attained by different men in the same position and having the same tool (the organization) with which to work. Methods are simply a means by which the artist (the management) manipulates the tools (the organization) at his disposal. In many cases, perhaps a majority, methods are more

or less a growth fostered by the necessity of the moment, a sort of patchwork with additions here and there to fill in a vacancy. Now we will discuss management and organization separately.

### MANAGEMENT

Management is the unseen force which drives all that is physical within a factory. It synchronizes human relationships and is by far the most vitalizing factor in our present industrial age. Machinery and materials may be put to work, workers may labor; but without adequate management to organize and consolidate them into a profitable, co-ordinate whole, to distribute the results of their work effectively, and to govern their operations during performance, this performance may become so uneconomic as to cease entirely. We are accustomed to think of the physical things: the shipyard, the wonderful machine, the useful product. We instinctively realize that some human force must have been called upon to create them, to bring them into being. But until recently, the methods of creating this force, of exercising its potentialities, were little thought of.

Management is very important in the shipyard. In regard to management, we must know what Mr. Taylor's system is. The Taylor system may be likened to a hydroplane, whose

component parts, such as gas engine, propeller, wings, float, wheels, etc., are not new in principle, but have been used previously in different combinations on other craft. But the particular combination as used on a hydroplane, together with certain new elements added by the inventor, embodies a new and distinct invention, - and such in management is the Taylor system. Mr. Taylor assembled and used well-established and well-recognized elements and principles of management from various sources embodying the best developments of modern industrial management in the United States.

The Taylor system of management contains the following elements:

- I. A careful study of the time required to do the work and detailing instructions to the men, telling them how to do their work.
- II. The payment of a premium for success accompanied by a corresponding loss in the case of failure.
- III. The thorough standardization of all details which affect the speed of the work.

These three elements outline the motive principles of the Taylor system, and it is seen that No. III relates to No. I since the purpose of instruction cards and standard conditions is to permit the time of an operation to be reduced to a minimum. No. II, the premium, and No. I, the time study, are the essence of the system. Without it, the definite,



clear-cut directions given to the foreman and the assigning of a full, yet just, daily task, with its premium for success would be impossible, and the arch without the keystone would fall to the ground. Thus, premium is the arch and time study the keystone of the Taylor system.

There is a growing realization through industry that one of the greatest opportunities for cost reduction lies in the improvement of existing production methods. The improvements do not necessarily have to be obtained by the installation of new and costly mechanical equipment; improvements of important magnitude can often be secured merely by analyzing the process and operations carefully, eliminating unnecessary work and motions and installing simple, practical, work-reducing methods. What is that? That is the three elements which America carried out carefully and accurately, so she won the war. From the point of view of the industrialization of China, these three important elements are not only suitable for her heavy industry, such as shipyards, but are also suitable for her general business. Now we will discuss these three elements separately, as follows:

#### TIME STUDY

The present trend toward increased efficiency in all kinds of work has brought about a widespread interest in motion and time study. There is always the problem of finding the most economical way of doing the task, and then of

determining the amount of work that should be done in a given period of time. This is ordinarily accompanied by some incentive plan of wage payment. Motion and time study provides the technique that is unequalled for finding methods of greatest economy and for measuring labor accomplishment.

It is because time study aims to do more than merely set time values that it has gained for itself such an important position in modern management. Because it eliminates waste of time, effort, and material, and because it increases output on standard operations and processes used in production work as a result of close study and searching analysis, time study work is now recognized by every progressive plant manager as a leading factor in the production of a high quality at a low cost and in a manner which improves labor relations. Motion and time study is composed of four parts, which will be explained more as follows:

#### I. Finding the Most Economical Way of Performing the Operation

The best way of doing a specific task is determined by a scientific study of the methods, materials, tools, and equipment used. Since all operations require some human effort or attention, a minute analysis of the movements made by the worker in performing his task is a valuable approach to the problem of finding the best way, optimum manner and method of maximum efficiency.

## II. Standardizing the Operation

After the best method for doing the work has been determined, this method must be standardized. The particular set of motions, the size, shape, and quality of material, the particular tools, jigs, fixtures, gauges, and the machine or piece of equipment to be used must be definitely specified.

## III. Setting the Time Standard

Time study may be used to determine accurately the standard number of minutes or hours that an average worker should take to perform the operation. This time standard converted into money value, as it often is, is called a piece rate. In other cases, the standard time value is used as a basis for any one of the many different incentive wage-payment plans. The most common method of measuring manual work is by means of a stop watch study.

## IV. Training the Operator

A carefully determined method of doing work is of little value unless it can be put into effect. It is necessary to train the operator to perform the work in the prescribed manner. The supervisor, motion and time study analyst, a special instructor, or skilled operator may act as the teacher. Where large numbers are trained, the training is sometimes carried on in a separate training department. Written instruction sheets as simple as possible, which are

valuable aids in training operators, and motion pictures are sometimes used for this purpose.

The above four elements are the most important in the time study, so far as we are concerned, which are important points for the management of the shipyard.

#### THE PREMIUM

The terms "bonus" and "premium" are both used by different authors to express the same idea in wage systems, and may be considered as equivalent terms.

In most of these systems nowadays the employee is guaranteed his day's wage, which is established upon a fixed basis, and the premium or bonus is the additional amount paid for performing a quantity of work over and above the amount established by the base rate. This base rate was formerly established by estimating from the shop records the best time in which the average workman could perform a given job. Such a method was in vogue until Mr. Taylor invented time study, by which the base rate, or task, as he called it, was determined, and the premium in this case was called a bonus; hence the task and bonus system, as it is called.

The idea back of task and bonus work is that an equitable bargain must be struck between the company and each employee. If the task is accomplished, the company will receive a definitely known minimum output at a lower total

cost per piece than under the older wage payment systems. In return for his effort to make the task which the company has set, not only does the workman receive a reward which is large enough to make him wish to accomplish this amount of work, but also he is guaranteed his hourly rate if he fail to reach the task. If he accomplishes the task, he is paid at his regular hourly rate for the time allowed for the task, plus a percentage of that time. This is equivalent to a high piece rate. Thus the workman has all the advantages of day work on a task he does not meet and all the advantages of high piece rates if he is proficient. The basing of the high rate on a day wage, although it takes the form of piece rate, allows different rates to be given different workmen, where this is desirable because of the varying lengths of their service, or differing all-round abilities. The task-and-bonus system is built on the idea of workers' earning the bonus every time. The bonus, under the task-and-bonus system, will be determined by the individual concern in accordance with its particular needs.

In day work the workman sells his time to the employer, and there is no measure of output. It is only necessary for the employee to perform a sufficient amount of work to satisfy his employer that he is earning his wage. This can be done and has been done by performing eye service, especially when watched, to create the impression of doing

a volume of work when no such volume existed. In order for the day work system to be at all acceptable, close personal supervision of the men by honest bosses is necessary, and a planning department is essential under any system of management.

It is to be noted here that in the day work system there is no incentive for the workman to produce a greater output in a given time, since if he does so he receives no extra reward but all of his extra output accrues to his employer; whereas, there are incentives for him to turn out less products in a given time, the idea being that the more goods created the less will be the future demand for work.

Piece work is the opposite extreme from day work. The piece-rate system of wage payment is a method to utilize after conditions had been standardized. The system has two piece rates, a high rate, and low rate. The high rate is set at a point considerably above the community standard while the low rate is set at a point below the standard of community. Under this system the incentive to the workman is the greatest of all, as he is not employer receives the benefit of all the direct wages involved in the increased output. It will be seen that this is the opposite effect from day work the tendency under piece work being to increase the output and that under day work to increase the time, and the overhead charge increases in proportion to the amount of time consumed on a job.

The peculiar thing about varying jobs is that there are so many circumstances inaccurate in the estimated unit time that it has been found necessary to guarantee the workman to lose his capital, which is more than he can afford to do. It is for this reason that the guarantee of the daily wage has been established in the various premium systems. Therefore, all jobs which are not so cut and dried as to have their unit time determined accurately in advance are not susceptible of being applied to piece work by the United States Government under existing law. This effect necessarily minimizes the application of piece work and leaves it available for such classes of work as plate, angle and rivet work, etc., to which it has heretofore been successfully applied for a long time in the past on account of the ability to measure and count the output per man.

Certain other classes of work, such as painting and manufactured articles, involving a standard output or repeat work, are available, but the sum total is comparatively small and limited to that which has heretofore been established under the straight piece work rates applied in navy yards.

Piece work has introduced a great bone of contention between employer and employee due to its inflexibility; the workmen receive all the increase in direct wages, and the work is essentially of such a nature that the workman can become familiar with the unit time required to do a given job.

The efficiency engineers have endeavored to meet this criticism by proclaiming it to be essential that premium rates should not be cut or altered in any way, excepting when the new and shorter method of doing the work has been discovered. These protestations have been superinduced by the workmen's opposition, and the object has been to break down the distrust of the workmen; consequently, one of the cardinal principles of scientific management has developed into a preachment of the gospel of the fair deal.

The group premium or contract system has been largely used for certain classes of work and is applied either on the premium or straight piece work plan. Also, in certain shops, such as a tin shop or a pipe shop or a boiler shop, where the bulk of the work can be carried out only by groups of men as distinguished from jobs that can be performed by individuals, the groups premium plan has been and is now used in certain large shipyards. Group premium, because it makes one worker desire to help another, results in developing all-round men. This is of importance at times when production must be decreased, for, by reducing the number of men in the group, production is cut automatically.

In regard to the payment of the shipyards, in our opinion it is better to apply straight piece work and group piece work or contract work to the hull construction work outside the workshops generally. Within the shops, straight



piece work and bonus or premium work is applied. In bonus work the men are allowed a certain number of hours upon a given job, and are given a premium of fifty per cent of the hours saved at their daily rate, being guaranteed and paid their daily wage whether a bonus is earned or not. Such a bonus system is in vogue in the pipe fitter's shop, the electrical shop, the ship carpenter's shop, the joiner shop, the sheet metal working shop, the machine shop, and the rigger's shop. Group piece work, or contract work, is in use in the blacksmith shop, the paint shop, the boiler shop, the plate and angle shop and the outside shipbuilding construction departments. Straight piece work is used in the pipe shop, the brass foundry, the plate and angle shop, and the outside shipbuilding construction departments. The machine shop as compared with the other shops is susceptible to the best application of the bonus system of payment.

#### STANDARDIZATION

Standardization of equipment tends very definitely to reduce maintenance cost in that the maintenance workmen become more familiar with the peculiarities of standardized machines and inventory of repair parts that must be carried for emergencies is reduced. This inventory factor is no small item. It works itself out in two ways. In the first place, if the machines are too varied, the keeping of repair

parts becomes so complicated and costly that an adequate supply of parts will seldom be kept. When this situation prevails, breakdowns become very costly, since production will be tied up unnecessarily or overtime has to be paid. In the second place, if adequate repair parts are kept, the total number is much greater for varied machines than where the machines are standardized.

Not only are inventories of repair parts reduced and maintenance kept to a minimum by standardizing equipment, but actual economies of production operation also follow. Workmen become accustomed to working with a given type of machine and can be transferred from one to another with relatively little loss in efficiency where the machines are standardized. This contributes to flexibility in the use of man power.

It should not be inferred that standardization of equipment required all machines of the same general type to be alike. It does mean that as far as practicable all machines performing the same identical operation should be alike. A six-inch production lathe will be used where the work requires this size and a twelve-inch lathe where the work requires that size. Occasionally a six-inch operation may be performed on a twelve-inch lathe when the other machines are in use.

Working toward standardized equipment, industry is constantly undergoing change. Improvements are continually

being made in both the machine tools and special purpose production machines. When a manufacturer decides to standardize his equipment he may be faced with the problem of what to do with his present equipment. The economist occasionally will justify standardization even at the cost of selling his old equipment at whatever price it will bring. Often this is not the case, yet it does not preclude a definite decision to standardize. Instead of replacing the present with the type decided upon for standardization all at one time, the desired equipment will be installed gradually as the older equipment is worn out. It may take some time to complete the standardizing process, but it is a goal toward which good management strives.

Special purpose equipment vs. standard machines. Standard machines, such as the lathe, grinder, planer, shaper, and drill press, have certain very definite advantages over special purpose machines. Standard in the sense that it is being used here refers to the general purpose machine. (It is possible to standardize the production of special purpose machines.) A few of the advantages of the standard or general purpose machines are as follows:

- (1) Increased flexibility in the range of the work that can be done.
- (2) Decreased initial investment in the equipment. The standard machine usually cost less largely because

they are produced in larger quantities and the cost of engineering is spread over a larger number of machines.

- (3) Possible decreased number of machines required to meet production needs arising from the increased flexibility.
- (4) More capable of meeting requirements of changes in design of the product or even a complete change in the nature of the product.
- (5) Easier to maintain balance in the equipment required and less dependent upon mass production.
- (6) Maintenance less expensive in that repair parts cost less and require less skill to install.

In the case of special purpose equipment, certain conditions must prevail in order to justify the expenditures necessary for installation.

These conditions are:

- (1) It is necessary that the market for the product be large enough to absorb the output of the special purpose equipment.
- (2) Product must be well standardized to make use of the special production machine.
- (3) Style and technical changes should be infrequent or volume sufficiently large to amortize the cost of equipment in a short time.

- (4) It is highly desirable that seasonal and cyclical variations in production be reasonably low.
- (5) Sufficient funds must be available to absorb the high fixed capital investment.

Where most of the foregoing conditions prevail, special purpose equipment has many advantages, a few of which are as follows:

- (1) The quality of the product tends to be more uniform.
- (2) Inspection costs are reduced.
- (3) A semi-skilled operator usually can be substituted for a more highly skilled man.
- (4) Output per unit of time is greatly increased, thus reducing the direct labor costs.
- (5) Factory floor space is usually less for the same volume of production.
- (6) A reciprocal relationship tends to exist between labor specialization, process specialization, and machine specialization.
- (7) Unit cost tends to be reduced.

The negative side of the advantages of standard purpose production equipment is in substance the disadvantages of special purpose machines, such as: less flexibility, increased capital investment, increased maintenance costs, greater difficulty in maintaining a balanced relationship in equipment, etc. Management is constantly faced with a

decision between the advantages of the general purpose machines and of the special machines. The volume of production and available funds bulks large in the final determination of the problem. Frequently a compromise between maximum specialization and general purpose equipment is reached.

The three elements which illustrated in the above are most important for managing an ideal shipyard. The ideas with which we are concerned are the advantages which reduce cost considerably and increase efficiency a great amount. Those ideas are major elements for running a shipyard

#### Other Considerations in Management

In a complex organization, such as a shipyard, the committee, or board system, has been found to be very valuable in modern management. Mr. Charles U. Carpenter in his "Profit-Making Management" first brought out and accentuated the advantages of such an arrangement. He believed in committees formed of the management and of leading heads of offices to insure cooperation, to supplement system in management so that the heads of a concern, though they cannot see everything, can come very near knowing everything or at least be in a position to sense danger, locate it, and eradicate its cause promptly. Through such cooperation, each member of the committee is brought to feel that the work of the whole is his product, which secures his cooperation. Such committee should act in an advisory capacity as to promotions,

final authority being vested in the superintendents. He believes further in subsidiary committees within the shop, as well as committees for conducting the management.

The advantages of the committee system have been recognized and applied in a great number of plants, and in recent years the practice has been widely extended in certain establishments though not so much in others. Even the navy yards have greatly profited in late years through the use of this system and the great shipyards likewise. In one shipyard the committee system is at a minimum, in another at a maximum. In nearly all there are committees in connection with the employment, rating and discharge of labor.

There should be a tri-weekly conference between the superintendents and the foremen to discuss all ways and means in connection with the work in progress in which all have an interest. There are additional meetings between the works managers, superintendents, and foremen whenever an occasion arises involving those called to be present. There is a committee on safety, a committee on suggestions, a committee to run the cooperative store, a special committee on premiums, a welfare committee, a committee on discharges to investigate complaints, a committee on apprentices, a committee on the yard lunchroom, a band and glee club committee, a committee on clubhouse and subcommittees of club members upon all different branches of athletics partaken of by the personnel of the establishment. There is a sick committee and a com-

mittee on fire department. In these committees all subjects are discussed, and everyone made a party thereto participates in a way to secure his intense and immediate interest. Every one has a right to be heard and has an equal voice in the discussions, subject of course to the usual reservation.

The principle of doctrine in management is worthy of mention in connection with the committee system. The role of doctrine finds its amplest field of application probably in naval warfare where, least of all, predetermined actions can be anticipated and covered by regulations and orders, so as to secure the right movement in every contingency. So, likewise, in shipyard management, the principle of doctrine is applicable.

Competition is another element which should be developed to the maximum extent as a principle in shipyard management. It is a well-known fact that where two ships, such as the Connecticut and the Louisiana, were built by competition between a navy yard and a private shipyard, as to time and cost, these vessels were produced in much quicker time and at less cost than any previous vessels not in competition.

The exception principle has been applied to modern management, which is a doctrine developed through experience whereby in a complex organization the manager has been shorn of all details and routine with which the old-time, one-horse management filled up his time. This doctrine is merely an authoritative notice to present day managers that they are



no longer expected to bury their heads behind a multitude of routine papers, or lose themselves in a mass of details, or be caught engaged in pursuing some particular pet hobby occurring among the minor industries of the plant.

The flowing records, such as are used in various branches of the work of an industrial plant. In shipyards a progress curve constitutes a flowing record, which conveys at a glance information affecting the progress of the work. Any kind of work can be thus analyzed by transferring the features under examination in the form of a curve or in the form of a diagram or a table. Shipbuilders make a picture diagram of the plating of a vessel, and by assigning different colors for the different months build up a flowing as well as a permanent record of the installation of the plates with respect to time.

The work board can be subdivided in any number of ways. The columns may be listed by shops, by trades, or by machines, and applied to any group of elements. There is no complex work but what should be broken up into its parts and fitted into a work board or progress curve, or progress sheet or some other form of condensed flowing record, and a little ingenuity will suffice to supply the needs in any important connection.

In a shipyard, the item of transportation is one of the big factors, in which there is an opportunity for loss unless the whole transportation problem has been broken

up into its elements and scientifically investigated, lost motions removed, and the problem bound together again at its lowest terms. There are an infinite number of permutations and combinations in this problem: it is frequently of vast proportions, it is expensive, and we dare say in a great number of plants furnishes the best field for savings as a result of scientific investigation and analysis.

In connection with transportation occurs the problem of efficient storage and supply materials, the location of the proper storehouses, the quantity of material to be carried in stock, their routes and channels of supply, and the efficiency of their purchase. All these are subject to analysis and improvement, especially considering that usually the work in the shops is a dependent sequence upon the supply of materials, and the latter must be made as completely subservient to the point of tool as any other element inside the shop.

The supply of materials is indeed very important problems and depend upon whether the plant is situated near a big city or whether it has millions of dollars' worth of supplies in storehouses.

Finally, the arrangement of buildings, transportation facilities, machinery, and other plant accessories must be given that careful consideration and analysis necessary in the first layout and in any subsequent readjustment. As the economics of a plant are important, the systems should

be bent and accommodated to short-cut methods and machines moved, modified or scrapped, and buildings rearranged and demolished, as all of these are secondary to the important developments in eliminating lost motions of past, for the reason that the time and current labor costs are of preponderating value and savings attainable have usually more than justified discarding obsolete equipment methods and arrangements as soon as shown by an adequate analysis to be desirable.

In accordance with the previous discussions, we can definitely say this kind of management is not only good for the naval shipyard but also good for any kinds of industries in China. If we can carry out this method carefully, we think it will be a big help in rebuilding China as a modern and a powerful country in the world.

### ORGANIZATION

The word "organization" is derived from the Greek word *ἔργον*, which means work and is akin to another form of the same word, *ὄργανον*, which means "an implement or instrument" for doing work. In Latin the word is "organum", and from this the English words "organ" and "organization" are derived, the latter applying to the complex work of modern times and indicating in its most modern application the frame work of personnel and their interrelations as an instrumentality for the performance of work. By organization

is meant the structure of enterprise, especially from the standpoint of the development of the duties and functions of the parts thereof. The purpose of building up an organization is to provide for a daily routine and effective operation of a business or department with a minimum of direction from above. Organization carries out its purpose by determining the scope and limits of each individual or group of individuals in a business undertaking, together with their relationships and contacts with each other. By a consideration of fundamentals and types of organization, an executive builds up a structure for his business which is peculiarly suited to its needs. The fundamentals of organization will differ widely in two different businesses:

- (1) The size of a business, particularly, has an effect on the way in which the organization develops.
- (2) The type of business will be found to affect greatly the development of the organization.

These two factors have a great effect on organization. The organization of big industries, like shipyards, is quite different from a simple store.

To build up an effective industrial organization requires proper observance and application of a series of "fundamentals of organization". These fall into two main groups, primary fundamentals and operating fundamentals.

(I) The primary fundamentals are fourfold:

- (1) Regard for the aim of the enterprise.
- (2) The establishment of definite lines of supervision.
- (3) The placing of fixed responsibility.
- (4) Regard for the personal equation.

(II) The operating fundamentals are four in number, also. They are:

- (1) The development of an adequate system.
- (2) The establishment of an adequate system.
- (3) The laying down of proper operating rules and regulations.
- (4) The exercise of effective leadership.

The above eight points are the fundamental elements of organization.

There are ~~four~~ methods of organization: the military method of organization; the line type of organization; and the functional type of organization and the line-and-staff organization.

#### I. The Military Method of Organization

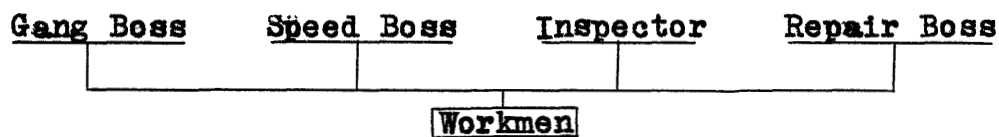
In the simplest form of this military type of organization, the boss was directly over all the workers in the organization except certain of the factory workers who might be under a foreman.

## II. The Line Type of Organization

In this type of organization responsibility and authority are definitely fixed, and it is effective in matters of discipline. On the other hand, it overloads a few men as the organization grows. Since the duties of these line executives cover all phases of activities, it is humanly impossible for them to be expert in all of them, with the result that the organization is deprived of expert advice in many important aspects. It would be rare for a man to be strong in all the requirements of the major executive duties and responsibilities.

## III. The Functional Type of Organization

This type of organization was introduced by Frederick W. Taylor, so they simply called it Taylor's functional organization. Mr. Taylor was convinced that the responsibilities of the old line foreman were greater than could be adequately borne by the men available. His solution for this situation was dividing up of these responsibilities among different men who were especially qualified for their special functions. He replaced the general foreman with four functionalized foremen as follows:



In setting forth his plan, Taylor pointed out that "It is because of the difficulty - almost the impossibility - of getting suitable foremen and gang bosses, more than for any other reason." He also pointed out that the qualities of a well-grounded man were as follows: "Brains, education, special or technical knowledge, manual dexterity or strength, tact, energy, grit, honesty, judgment or common sense, good health." He felt that three of these qualities could be hired at any time for laborer's wages. If four were added together, it was necessary to secure a high-priced man. The man combining five was hard to find, and the one with six, seven or eight almost impossible to discover. From what he said, this system was hard to carry out, especially hard to carry out in a country like China. But this organization has its advantages, which may be listed as follows:

- (1) Specialized skills are brought to the individual workmen.
- (2) It is possible to find supervisors in sufficient numbers who possess the required special abilities.
- (3) The separation of manual from mental work takes advantage of the principle of specialization.

The major disadvantages of functional organization are:

- (1) It tends to complicate problems of discipline among the lower levels of the organization.

- (2) The coordination of the efforts of the various functional foremen is difficult.
- (3) It tends to narrow specialization among executives and workers.

From the above points of view, this organization is no longer suitable to carry on in a country like China. China needs the organization which not only has the advantages of the functional organization but also has the advantages of the military organization.

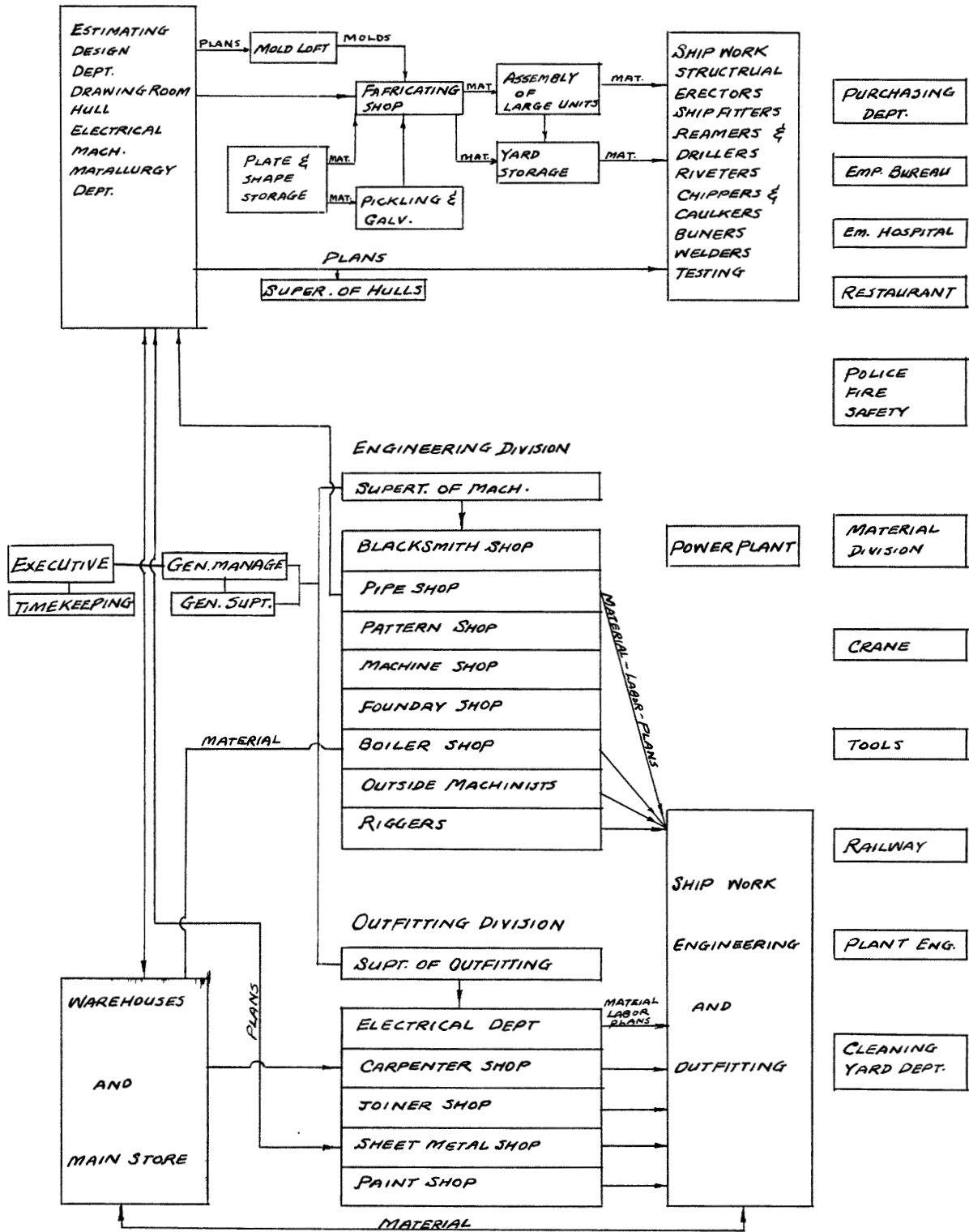
#### IV. Line-and-staff Organization

The name "staff" could, in this illustration, be very fittingly applied to those entities radiating from the president excepting in the one vertical line leading through the general manager to the plant, which might be called the line. That is to say, the word "staff" might be applied to treasurer, assistant auditor, production engineer, vice-president, naval architect, chief engineer, and estimator; and to said staff of the president could be added the staff of the vice-president and general manager in the additional offices of sales agent, purchasing agent, assistant mechanical engineer, and head in charge of training apprentices. Hereafter, we will call these the staff as they relate to the organization. The line we would call that channel of control of the plant proper through the officials indicated in the



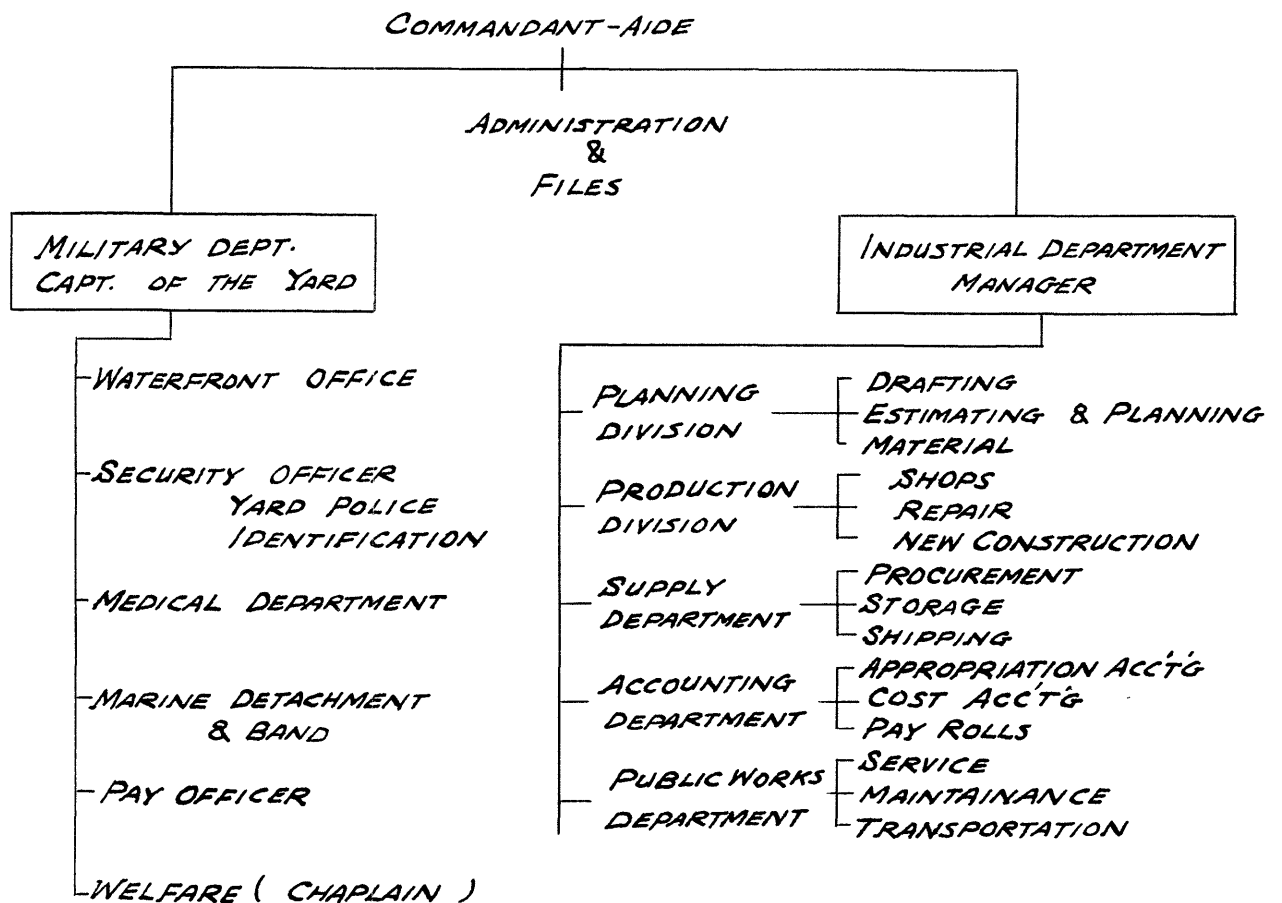
vertical center line from Board of Directors to the president, vice-president-and-general-manager, to general superintendent, to foremen.

In accordance with these four types of organization, each one has its advantages and disadvantages. It seems to us that the line-and-staff organization has practically all the advantages of both the military and functional organizations with relatively few of their disadvantages. In a gigantic industry like a shipyard, the organization is more complicated, but the main idea is to follow the line-and-staff method. A typical organization chart was issued by the Massachusetts Institute of Technology. It is illustrative of a typical shipyard organization, as follows:

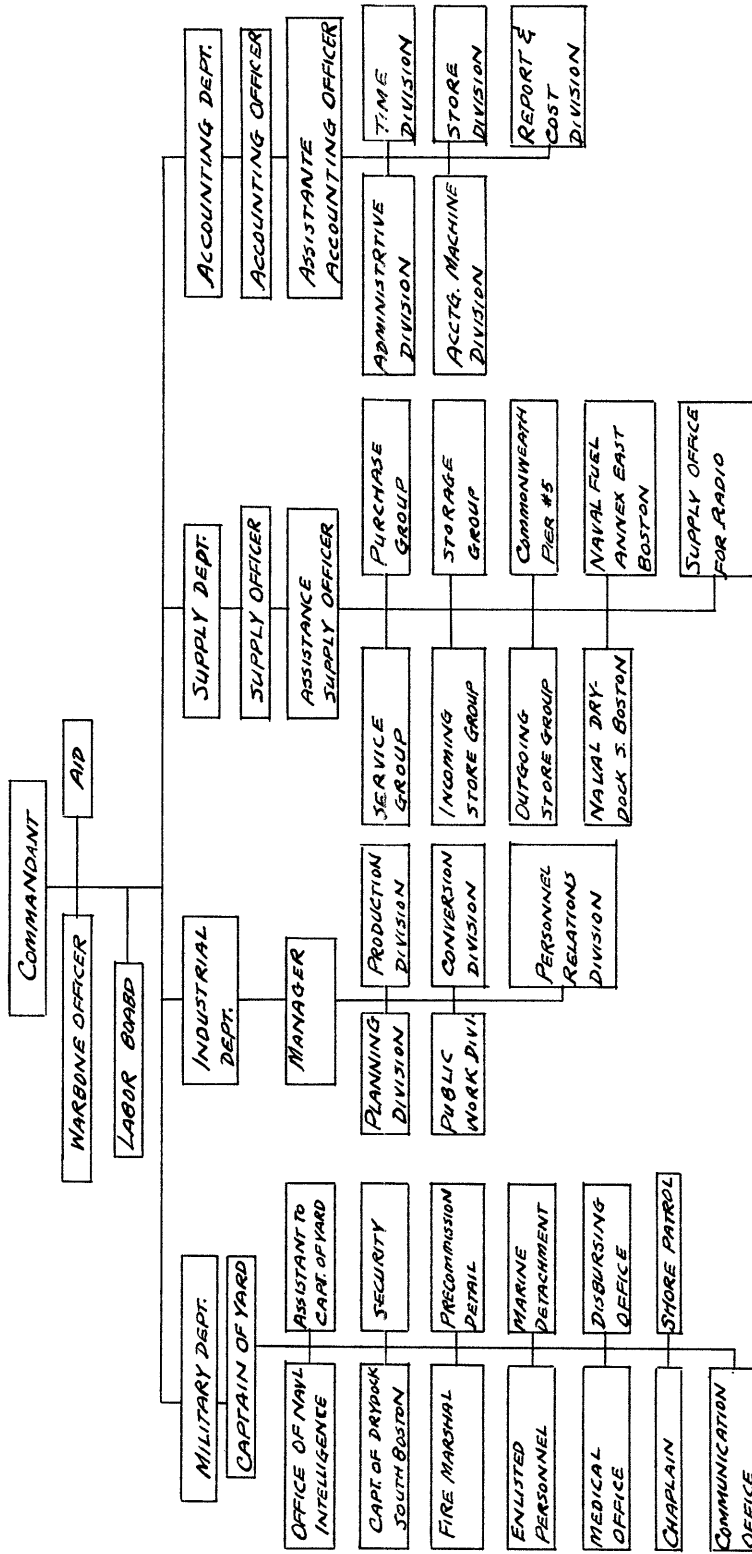


The lecture SL5 on organization of navy yards was given by a professor of the Naval Architecture Department at the Massachusetts Institute of Technology, and was illustrated as follows:

ORGANIZATION OF NAVY YARDS



The general organization of the Boston Navy Yard was issued in 1945 as follows:



ORGANIZATION OF BOSTON

NAVY YARD

The above organizations we are using as a basis to presume a standard shipyard organization for the Chinese Navy in accordance with its necessities. We chose the advantages and eliminated the disadvantages from the above charts to develop a standard organization chart as follows:

#### The Commander

The commander is responsible for the administration of the navy yard; he supports the policies and executes the orders of the ministry of navy; he is entirely responsible to the ministry of navy for the coordination and conduct of the affairs of the navy shipyard.

There are four staff officers as a head of each division under the Commander which are as follows:

- (1) Industrial Engineering Officer.
- (2) Electronics Officer.
- (3) Industrial Relations Officer.
- (4) Ordnance Officer.

Four divisions which are Management Planning, a review division, Industrial Relations Division, Electronics Division, and Ordnance Division.

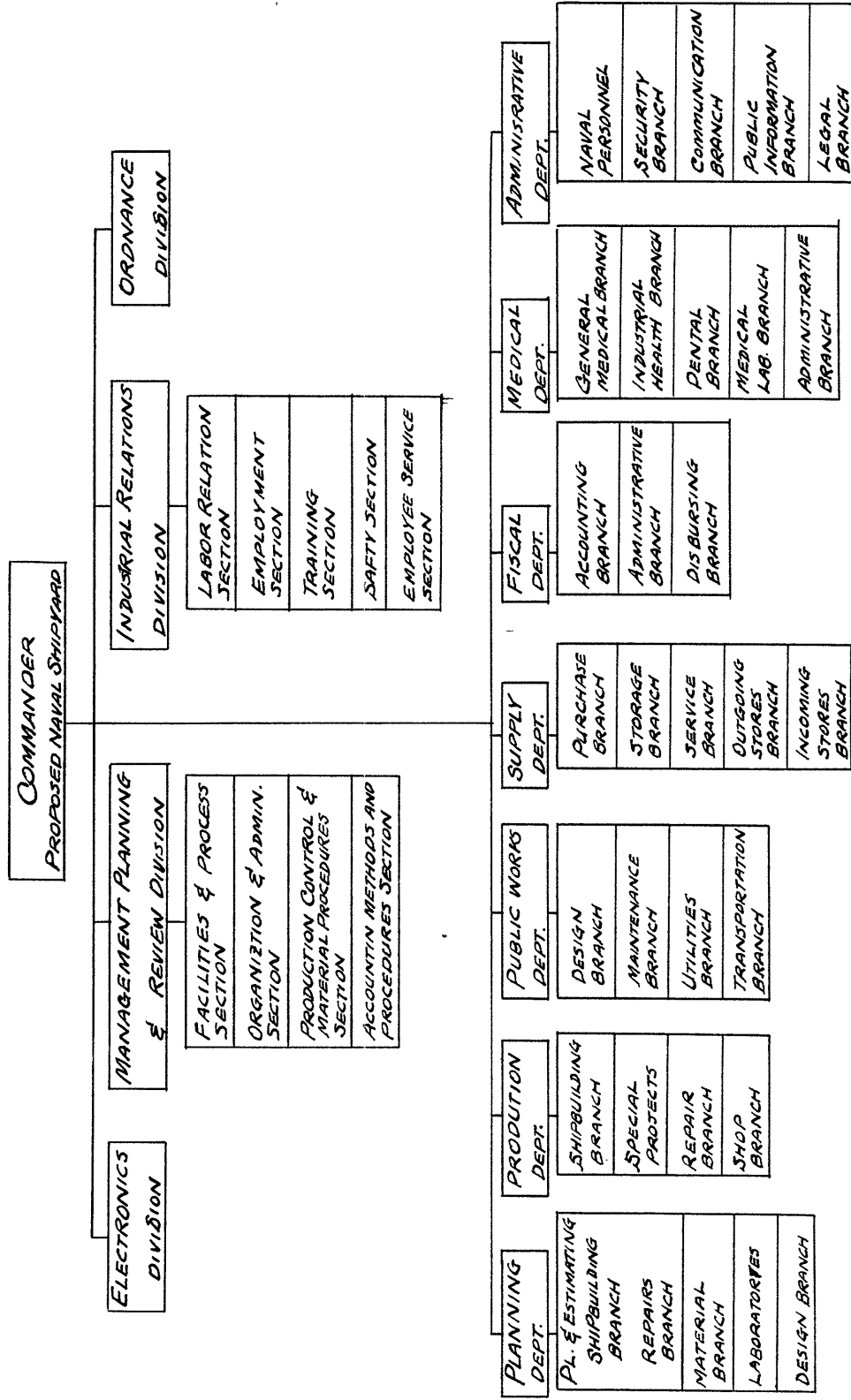
#### Departments of Naval shipyard

The naval shipyard is composed of seven principal departments. These departments and titles of their heads are as follows:

(1) Planning Department	-	Planning Officer
(2) Production "	-	Production "
(3) Public Works "	-	Public Works "
(4) Supply "	-	Supply "
(5) Fiscal "	-	Fiscal "
(6) Medical "	-	Medical "
(7) Administrative "	-	Administrative "

It is the duty of the officers in charge of these eight departments of the naval shipyard to keep the Commander informed:

- (a) Of the progress of work assigned within their departments with particular emphasis regarding the completion of vessels under construction or repair.
- (b) Of the immediate and anticipated work load.
- (c) Of the condition of yard facilities and their improvement.
- (d) Of the personnel, including all changes that may be found advisable.



## Planning Department

### The Organization of the Planning Department

The Planning Department is composed of a Planning Office, a Material Branch, Laboratories, and a Design Branch; an officer in charge of the Planning Department, an Administrative Assistant as a staff to the Planning Office, and four superintendents under the office.

#### I. The Planning Office

The Planning Office is composed of two branches and five sections. Their names are as follows:

- (a) The shipbuilding branch: an assistant planning and estimating superintendent in charge.
- (b) The repairs and manufacturing branch: an assistant planning and estimating superintendent in charge.
- (c) The five sections under these two branches, which are named: hull section, machinery section, ordnance section, electrical section, and electronics section.
- (d) Each section has an assistant planning and estimating superintendent in charge .
- (e) A senior civilian assistant to assist the planning and estimating superintendent.

#### II. The Material Branch

The Branch consists of one senior civilian assistant and two assistant material superintendents. An assistant material superintendent is in charge of each section.



### III. The Laboratories

The Laboratories have a laboratory superintendent in charge of several laboratories.

### IV. The Design Branch

- (a) The Design Branch is divided into four sections under the design superintendent; each section has an assistant in charge.
- (b) A senior civilian assistant acting as an assistant to the Design Branch.
- (c) The four sections named as ordnance section, hull section, machinery section, and electrical section.

### The General Duties of the Planning Department

- I. The Planning Officer is responsible to the Commander of the naval shipyard for the administration of the planning Department and the accomplishment of all work performed by it.
- II. The administrative assistant in charge of three parts, which are named organization administration, process control, and personnel, who works directly as a staff to the Planning Officer.
- III. The Planning Office:
  - (a) The planning and estimating superintendent is the representative of the planning officer. He is responsible to him for the administration of the office.

- (b) Advance planning for vessels which are scheduled to be overhauled at the naval dry dock.
  - (1) Prepare specifications, order plans and material for work, which can be undertaken during the forthcoming availability.
  - (2) Review of all correspondence, departure reports, transfers of work, etc.
  - (3) Obtain project orders and issue job orders in accordance with outstanding instructions.
  - (4) Review advance work lists of vessel and order material and plans.
- (c) Inspect work items requested by vessels and recommend method of repairing to Planning Officer.
  - (1) Prepare specifications for work items for release.
  - (2) Order material required by jobs through Material Section.
- (d) Prepare time and cost estimates as requested.
- (e) Maintain ready reference list of commonly used equipment for use in emergency replacement.
- (f) Prepare departure reports.

#### IV. The Material Section

- (a) Initiate action for procurement of material required by the naval shipyard.
- (b) Determine local source of supply, when information is available.

- (c) Place follow-up of special material on hand in Material Section, and maintain active card file on this material showing status as obtained. Follow-up quick purchase requisitions through Material Section.
- (d) Screen material and progress sheets for critical material, non-essential requisition, etc.
- (e) Note all pertinent information on material and progress sheets. Distribute these to all interested shops and activities.
- (f) Maintain active file of all shipment "serial letters" for material shipped from one naval shipyard to another naval vessel, contractors and various other places.

#### V. The Duties of Laboratories

- (a) Plan photographic laboratory. Is responsible for exposures from blue prints on photographic paper. Makes enlargements and reductions of plans; makes multilith zinc and paper plates; makes "See-Bee" process tracings, and vandykes and prints for special purposes.
- (b) Photographic Laboratory. Is responsible for photographic work of technical, legal, publicity, and historical value.
- (c) Material Laboratory. Is responsible for making a large number of inspection tests as well as many material approval tests.

- (d) Welding Laboratory. Is responsible for investigating all processes for ship welding.
- (e) The gyro compass repair group for the yard is also under laboratory supervision.
- (f) Technical assistance or advice is here available to other departments, sections, and branches of yard, particularly in connection with metallurgical and general chemical questions.

#### VI. The Duties of Design Section

- (a) The design superintendent is responsible to the Planning Officer for all questions of design.
- (b) He is charged with the preparation and approval of ship plans.
- (c) He is responsible for the administration and reporting of authorized tests and investigations, preparing reports of each test.
- (d) He is responsible for preparation of machinery indexes and test schedules.
- (e) He is responsible for the preparation of specifications for special material or equipment to be purchased by the yard.
- (f) He is charged with the administration of the blue print room as well as of the drafting room.
- (g) The assistants to the design superintendent will perform such duties as assigned them by the head of the design section.

These illustrations are the general organization and duties of the Planning Department.

### Production Department

The Production Department is the department which is responsible for building all new ships; for special projects such as ship salvage, ship preservation; for ship repair, and the shops.

The production officer has full responsibility to the head of the naval shipyard. He is responsible for administering all kinds of work to the subsections.

### The Organization of the Production Department

There are four sections and one administrative assistant which are under the direct control of the Production Department. The former consists of shipbuilding section, special project section, repair section, and shop section. Each section has a superintendent as the head of the section. The latter consists of office organization, office administration, personnel records, scheduling and progress, inspection and finance. They are staff to the Production Department.

- I. The shipbuilding section is divided into five branches: they are the hull, the machinery, the ordnance, the electrical, and the electronics. Each branch has an assistant shipbuilding superintendent as its head.
- II. The special projects section has a specialist assistant for special projects.

- III. The repair section is the same as the shipbuilding section, which is also divided into five branches and has five assistant superintendents as the head of each branch.
- IV. The shop section is composed of three branches: they are the administration, the procedures and the plant. Each branch has its assistant shop superintendent who is directly under the shop superintendent.

The General Duties of Each Section of Production Department

- I. The production officer has full responsibility to the head of the naval shipyard. He is responsible to administer all kinds of work to the subsections.
- II. The duties of shipbuilding section.
- (a) The shipbuilding superintendent is the head of the shipbuilding section, and he is responsible to the head of the production department.
  - (b) He is responsible for answering all questions about building a new ship.
  - (c) He has to make schedules for shipbuilding.
  - (d) He is responsible for the preparation of specifications, for getting new materials and equipment from the supply department.
  - (e) He is responsible for the preparation of all the work to be assigned to each branch.

- (f) He is responsible for maintaining close contact with the design section of the planning department.
- (g) The five branches are his assistants.

III. The duties of special projects section.

- (a) The superintendent of this section has the responsibility of repairing all kinds of ships under the direction of the production officer.
- (b) He is responsible for solving the problem of all kinds of damage.
- (c) He is responsible for preserving all kinds of wrecks.

IV. The duties of repair section.

The duties for which the superintendent of the repair section is responsible are the same as those of the superintendent of the shipbuilding section, except one is for building new ships and the other is for repairs only.

V. The duties of shop section.

- (a) The superintendent of the shop section is directly responsible to the production officer.
- (b) He is responsible for fabricating all the structures which the shipbuilding section and the repair section need.
- (c) He is responsible for arranging the work which the branches under him should do.

- (d) The branches under him have the duties of personnel training, administration, organization, personnel records report, production procedures, materials distribution, storage production processes, methods, equipment, facilities and shop stores.

The above illustrations are the general organization and the duties of the production department.

### Public Works Department

#### The organization of the public works department

The public works department has a public works officer and an assistant public works officer. There is a deputy officer under the direction of the public works officer. There are two sections working as a staff relatively to the public works officers, and four branches which are directly under the administration of the public works officers. The two sections are the administrative and financial section and the progress control section. The four branches are the design branch, the maintenance branch, the utilities branch, and the transportation branch.

#### The General Duties of the Public Works Department

- I. The public works officer is the head of the public works department and is in charge of its administration and responsible for the proper functioning of the department. His duties include:



- (a) Responsibility to the head of the yard for the work of the public works department and compliance with the policies of the commandant and directives of higher authority relating to the work of the department.
- (b) Technical advisor on matters in line of his profession.
- (c) Annual inspection of public works and public utilities.
- (d) Preparation of annual estimates for public works developments together with such plans and specifications as may be required.
- (e) Officer in charge of construction on all contracts under the Bureau of Yards and Docks.
- (f) Charge of officers of the Civil Engineer Corps ordered to duty in the public works department and such other officers as may be assigned by the commandant to this department.

II. The assistant public works officer shall be executive officer and acting public works officer in the absence of the latter. He shall be responsible to the public works officer for all matters pertaining to the work of the department, including:

- (a) The coordination and effective utilization of the design, maintenance, utilities, and transportation branches.

- (b) Control and coordination of all matters pertaining to funds allocated to the public works department.

### III. The Deputy Officer

- (a) He is directly responsible to the public works officer.
- (b) He is in charge of construction contracts.
- (c) He is responsible for supervision and inspection of construction contracts.

### IV. The Administrative and Financial Section

- (a) The head of this section is the staff relatively to the public works officer.
- (b) He is responsible for the preparation of requisitions.
- (c) He is in charge of financial control and reports.
- (d) He is responsible for administration of real estate and office space.
- (e) He is in charge of mail files and personnel records.

### V. Progress Control Section

- (a) The head of this section is the staff relatively to the public works officer.
- (b) He is in charge of the progress of public works projects.
- (c) He is responsible for investigating and screening requests for new projects.
- (d) He is responsible for fire inspection, boiler inspection, and annual inspection.

## VI. The Design Branch

The design superintendent is the head of the design branch and is responsible for:

- (a) The preparation of all drawings, specifications and estimates for all public works construction.
- (b) Accurate preparation of all public works maps and charts, including the making of surveys and taking of soundings required.
- (c) Furnishing technical advice to the other public works activities through the cognizant branch superintendent.
- (d) Preparation of all reports and correspondence having to do with design activities.
- (e) Maintenance of drawing, photographic and technical report files.
- (f) Checking of contractor's shop detail drawings.
- (g) Annual and periodic inspection.
- (h) Maintenance of data for plant account pertaining to land and structures and corrections.

## VII. The Maintenance Branch

The maintenance superintendent is the head of the maintenance branch and he is responsible for the following:

- (a) Construction, maintenance and operation of public works.

- (b) Effective control of all projects to secure full compliance with specifications for work assigned to the building trade shop, to prevent expenditures above authorized amounts and to insure completion of the work assigned within the time allowed.
- (c) Supervision of the procurement and inspection of material for shop use.
- (d) Maintenance in a clean and orderly condition of buildings, storage and work areas.
- (e) Procurement, maintenance, and inventory of officers' quarters, furniture and furnishings.
- (f) Assembly of data, preparation of reports.

#### VIII. The Utilities Branch

The utilities superintendent is the head of the utilities branch and he is responsible for the proper upkeep and functioning of the central power plant, central heating plants, including the associated steam, hot water, compressed air, hydraulic and electric distribution systems. His duties include supervision of:

- (a) The operation of the central power plant and central heating plants and associated distribution systems to insure efficient and economical operation.

- (b) The maintenance, inspection, repair and alteration of power and heating plant equipment and associated distributing systems.
- (c) Installation, maintenance and repair of the cable facilities provided for yard communication systems.
- (d) Operation of graving and floating drydock pumping plants.
- (e) The maintenance in a clean and orderly condition of all buildings, storage, and work areas assigned to this branch.
- (f) Assembly of data, preparation of reports.

IX. The Transportation Branch

The transportation superintendent is the head of the transportation branch and is responsible for the supervision of all transportation activities over which the public works department has cognizance, including the following:

- (a) The maintenance, repair, and inspection of the railroad rolling stock and locomotives, mobile weight handling equipment, trucks, passenger vehicles and special equipment for earth moving, snow removal and street sweeping.
- (b) Shop operations to insure an efficient and economical weight handling and transportation service.

- (c) Procurement and assembly of new units of equipment.
- (d) Procurement of parts, material and equipment required for maintenance and repair of operating units.
- (e) Services performed to his order by other shops.
- (f) Enforcement of safety rules and regulations insofar as they pertain to the transportation branch.
- (g) The maintenance in a clean and orderly condition of buildings, storage and work areas assigned to the transportation branch.
- (h) Assembly of data and preparation of reports.

### Supply Department

#### The Organization of the Supply Department

The supply department is divided into five branches. They are: purchasing branch, storage branch, service branch, outgoing branch, and incoming stores branch. Each branch has a superintendent in charge. There are two officers: one supply officer and one assistant supply officer.

#### The General Duties of the Supply Department

- I. The supply officer is the head of the supply department. He is responsible for the purchasing, storage, service, outgoing and receipt.
  - (a) He is responsible for the issuing of all classes of material, including fuel.

- (b) He is responsible for the use of stub requisitions and return material stubs.
- (c) He is responsible for turning material into store, surveys, sales, shipment of all classes of material.
- (d) He is responsible for the receipt and disposition of ships' requisitions and the issuing of material and stores to ships and shops.
- (e) He is also responsible for the operation and policing of storage spaces and storage warehouses both within and without the navy yard, and commercial steamship piers acquired for navy use.

II. The assistant supply officer shall be executive officer and acting supply officer in the absence of the latter. He shall be responsible to the supply officer for all matters pertaining to the work of the department.

III. The purchasing branch

- (a) The purchasing superintendent is the head of the purchasing branch and has the responsibility of administering all the work in this branch.
- (b) He is responsible for purchasing all kinds of material which the yard needs.
- (c) He is responsible for making proposals for materials to be purchased.
- (d) He has the responsibility of making contracts.

(e) He is responsible for awarding the men under his control.

(f) Assembly data and preparation of reports.

#### IV. The storage branch

(a) The storage superintendent is the head of the storage branch and has responsibility for arranging all kinds of material stores.

(b) He is responsible for shop stores and fuel.

#### V. The service branch

(a) The service superintendent is the head of the service branch and he administrates all the matters within this branch.

(b) He is responsible for the bookkeeping.

(c) He is responsible for making inventories.

(d) He is responsible for assembly data and preparation of reports.

#### VI. The outgoing branch

(a) The outgoing branch superintendent is in charge of this branch.

(b) He is responsible for issuing the requisitions and invoices.

(c) He is responsible for assembly and packing.

(d) He is responsible for delivery.



## VII. The incoming stores branch

- (a) The incoming stores superintendent is in charge of this branch and is responsible for the receipt of all kinds of material.
- (b) He is responsible for receiving all kinds of material, inspection and reports.
- (c) He is responsible for making public vouchers.
- (d) He is responsible for material inspection, stock control, and stock upkeep.
- (e) He is responsible for making requisitions and orders.

### The Fiscal Department

#### The Organization of the Fiscal Department

The Fiscal Department is composed of three branches, which are: accounting branch, administrative branch, and disbursing branch.

The fiscal officer is the head of the fiscal department. There are three superintendents under his direct control, namely, accounting superintendent, administrative superintendent, and disbursing superintendent.

#### The General Duties of the Fiscal Department

- I. The fiscal officer is the head of the fiscal department and he is in charge of the three branches, which are the accounting branch, the administrative branch, and the disbursing branch. Each branch has a superintendent in

charge but he is fully responsible for directing these three branches in accordance with the accounts, reports and costs, personnel and civilian disbursing.

II. The accounting branch

- (a) The accounting superintendent is the head of the accounting branch.
- (b) He is responsible to the fiscal officer.
- (c) He is responsible for handling pay accounts, preparation of payrolls and service records for civilian employees.
- (d) He is responsible for cost accounts and such other accounting activities.

III. The administrative branch

- (a) The administrative superintendent is in charge of the administrative branch and is responsible to the fiscal officer.
- (b) He is responsible for personnel affairs.
- (c) He is in charge of files.

IV. The disbursing branch

- (a) The disbursing superintendent is in charge of the disbursing branch.
- (b) His responsibilities include carrying the accounts of the officers and civilian payroll of the naval shipyard and issuing pay checks, together with other fiscal duties, in accordance with regulations.

## Medical Department

### The Organization of the Medical Department

There are five branches of which the medical department is composed: the general medical branch, the industrial health branch, the dental branch, the medical laboratory branch, and the administrative branch. Each branch has an officer in charge.

### The General Duties of the Medical Department

- I. The medical officer is the head of the medical department and is in charge of the general medical branch, the industrial branch, the medical laboratory branch, and the administrative branch.
- II. The general medical branch  
The medical officer is in charge of this branch and his duties include the following:
  - (a) Medical care and physical examinations for naval personnel.
  - (b) Physical examinations for eligible civilian personnel.
  - (c) First aid and medical care for personnel incapacitated on duty.
- III. The Industrial Health Branch  
The medical officer is the head of this branch and has the following duties:
  - (a) He is in charge of preventive medicine.
  - (b) He is responsible for industrial hygiene and sanitation.

#### IV. The Dental Branch

The dental officer is in charge of this branch and has the following duties:

- (a) He is responsible for dental care for naval personnel.
- (b) He is responsible for dental examinations for eligible employees and employees.

#### V. The Medical Laboratory Branch

The medical officer is in charge of this branch and has the following duties:

- (a) He is in charge of examinations.
- (b) He is in charge of tests and analyses.
- (c) He is in charge of dispensary.
- (d) He is responsible for clinical practices.

#### VI. The Administrative Branch

The medical officer is in charge of this branch and has the following duties:

- (a) He is responsible for personnel and property control.
- (b) He is in charge of accounting.
- (c) He is in charge of medical records.
- (d) He is responsible for the assembly of data and preparation of reports.

## The Administrative Department

### The Organization of the Administrative Department

The administrative department has two officers: one is the administrative officer, and the other is the assistant administrative officer. There are five branches in this department, which are: the naval personnel branch, the security branch, the communications branch, the public information branch, and the legal branch. The first three branches are in charge of three superintendents; the last two branches are in charge of two assistants.

### The General Duties of the Administrative Department.

- I. The administrative officer is in charge of the administrative department. He is responsible for administrating the suitable duties to each branch.
- II. The assistant administrative officer shall be executive officer and acting administrative officer in the absence of the latter. He shall be responsible to the administrative department.
- III. The Naval Personnel Branch

The naval personnel superintendent is the head of this branch and has the following duties:

- (a) He is responsible for officer personnel and enlisted personnel.
- (b) He is in charge of commission details and watch officers
- (c) He is in charge of tugs, small crafts' pilots.

#### IV. The Security Branch

The security superintendent is in charge of this branch and is responsible for the following:

- (a) He is in charge of police.
- (b) He is in charge of traffic and parking.
- (c) He is responsible for intelligence.
- (d) He is in charge of guards.

#### V. The Communication Branch

The communication superintendent is in charge of this branch and has duties as follows:

- (a) He is in charge of central files and correspondence.
- (b) He is responsible for communications watch.
- (c) He is responsible for decoding and visual signaling.
- (d) He is in charge of telephone operations and post office.

#### VI. The Public Information Branch

The public information assistant is the head of this branch and is responsible for all public information.

#### VII. The Legal Branch

The legal assistant is the head of this branch and is responsible for all kinds of legal problems for the naval shipyard.

## Industrial Relations Division

### The Organization of the Industrial Relations Division

The industrial relations division is composed of five sections, which are: labor relations section, employment section, training section, safety section, and employee services section. Each section has a superintendent in charge.

There are two assistants under the industrial relations division: one is civilian industrial relations assistant, and the other is assistant to industrial relations officer for special studies and reports.

### The General Duties of the Industrial Relations Division

The industrial relations division consists of one officer, two assistants, and five superintendents. Their duties are as follows:

- I. The industrial relations officer is the head of the industrial relations division and is in charge of the five sections. He is responsible for arranging and distributing the duties to each of the sections. He is a staff to the head of the naval shipyard.
- II. The assistants - who shall be executive officer and acting industrial relations officer in the absence of the latter. One shall be responsible for civilian industrial relations and the other shall be responsible to the industrial relations officer for special studies and reports.

### III. The Labor Relations Section

- (a) The labor relations superintendent is the head of this section.
- (b) He is responsible for employee grievances.
- (c) He is responsible for group dealings.

### IV. The Employment Section

The employment superintendent is the head of this section and has the following duties:

- (a) He is in charge of employment, re-ratings, separation, etc.
- (b) He is responsible for placement.
- (c) He is in charge of efficiency ratings.
- (d) He is in charge of retirement and personnel records.
- (e) He is in charge of wages and hours.
- (f) He is responsible for disciplinary review.
- (g) He is responsible for veterans' placement advisor.
- (h) He is in charge of personnel statistics, reports, etc.
- (i) He is responsible for job analysis and classification.

### V. The Training Section

The training superintendent is the head of this section and his duties are as follows:

- (a) He is in charge of trades and apprentices.
- (b) He is responsible for instructors.
- (c) He is responsible for technical and scientific



- (d) He is responsible for supervision.
- (e) He is responsible for indoctrination.

#### VI. The Safety Section

The safety superintendent is the head of this section and has the following duties:

- (a) He is responsible for safety engineering.
- (b) He is responsible for safety education.
- (c) He is responsible for accident analysis.
- (d) He is responsible for compensation.

#### VII. The Employee Services Section

The employee services superintendent is the head of this section and his duties are as follows:

- (a) He is in charge of foot service.
- (b) He is responsible for employees' periodical, social and recreational activities.
- (c) He is responsible for group hospitalization and credit union.
- (d) He is in charge of beneficial suggestions.

#### Management, Planning and Review Division

#### The Organization of the Management, Planning and Review Division

This division is composed of four sections, which are: the facilities and process section, the organization and administration section, the production control and material procedures section, and accounting methods and

procedures section. The industrial engineering officer is in charge of this division. There are four superintendents under him, whose names are: the facilities and process superintendent, the organization and administration superintendent, the production control and material procedures superintendent, and accounting methods and procedures superintendent.

The General Duties of the Management, Planning and Review Division

The management, planning and review division consists of one officer and four superintendents. Their duties are as follows:

I. The industrial engineering officer is the head of this division and is acting as a staff to the head of the naval shipyard. He has four superintendents under him working in accordance with his directions and arrangement. He is responsible for directing them.

II. The Facilities and Process Section

The facilities and process superintendent is the head of this section and is in charge of:

- (a) Plant and facilities.
- (b) Production and manufacturing process review.

### III. The Organization and Administration Section

The organization and administration superintendent is the head of this section and has the following duties:

- (a) He is responsible for the organization and management of the yard.
- (b) He is responsible for statistics and reports analysis and service.
- (c) He is responsible for developing a suitable administrative method for the yard.

### IV. The Production Control and Material Procedures Section

The production control and material procedures superintendent is the head of this section and has the following duties:

- (a) He is responsible for the production control.
- (b) He is responsible for material procurement, storage, handling and distribution.

### V. The accounting method and procedures sections

The accounting method and procedures superintendent is the head of this section and has the following duties:

- (a) He is responsible for costs and budget.
- (b) He is responsible for deciding the procedures.

## The Electronics Division

### The Organization of the Electronics Division

It is divided into several groups, such as radio, radar-search, sonar, radar-ordnance, and other groups should be added to cover the electronics field. Each group has a superintendent to take charge and an officer is in charge of groups.

### The General Duties of the Electronics Division

- I. (a) The electronics division officer is in charge of the electronics division and is responsible for general supervision, coordination and technical approval of all plans involving electronics equipment and devices normally assigned to an electronics division.  
(b) He is responsible to the production officer for installation, testing and calibration of electronic equipment for all activities of the navy yard.  
(c) He requires correlation with all yard activities involving any planning work, installations or maintenance coming under the head of electronics, which term is applicable to radio, sonar, radar, cryptographic, teletype, harbor detection, and other devices closely related to electronic equipment.
- II. The electronics officer and his superintendent are responsible for the following regular and collateral duties:

- (a) Operation of electronic schools within the geographic limits assigned to this yard for the instructions of electronics.
- (b) Direction of the activities of electronics laboratories.
- (c) Planning, supervision, and performance of electronics installations and maintenance on ships at navy yard and at shore.
- (d) Making such inspections of electronic work underway or accomplished as are required to insure the effectiveness and completeness of such work.
- (e) Accomplishment of such research, experimental, development, test and other work assigned by the Navy Department.
- (f) Inspection of shore electronic activities as may be required.
- (g) To cooperate with public works officers concerning annual public works inspections of shore radio station.
- (h) To coordinate the activities and security of the cryptographic repair facility with the requirements of the communication officer.
- (i) To collaborate with supply officers as regards electronic supply matters and stock required.
- (j) To provide technical assistance required by supply officers for the purpose of screening requisitions and identifying electronics material.

(k) To prepare estimates for:

1. Ordinary maintenance, maintenance projects, and special projects for shore electronic activities.
2. The establishment of new shore electronic activities.
3. Ship electronic repairs and alteration at yards.

III. The electronic officer and the superintendent is responsible for the performance of all the specific duties outlined above.

#### Ordnance Division

##### The Organization of the Ordnance Division

The Ordnance Division is divided into several groups according to the type of ordnance and the needs of the ship. No information was available in regard to this due to naval secrecy.

The ordnance division has an officer in charge. There are several group superintendents responsible to him.

##### The General Duties of the Ordnance Division

- I. (a) The ordnance officer is the head of this division and is in charge of all ordnance which the yard needs for the proper ship.
- (b) The ordnance officer coordinates all action among yard activities which involves Bureau of Ordnance

Cognizance. To accomplish these purposes, the ordnance officer is assigned under the head of the naval shipyard and fully cooperates with both the planning officer and the production officer.

- (c) The ordnance officer controls the release of critical ordnance material from the supply department.

II. The superintendents of this division are assistants to the ordnance officer.

The above descriptions of organization are merely just like blood in the blood vessels of mankind. If any one of the blood vessels gets in trouble, the whole body will feel uncomfortable. The organization of the naval shipyard is just like a man's body: if any department or any section or any group does not have a good organization, the whole business will get in trouble, at least will have lower efficiency. The purpose of organization is to increase efficiency. Our idea in developing such an organization chart is merely to eliminate waste of time and to increase efficiency.

In the previous discussion of both management and organization, we can definitely say that management is an art and organization is a science; and, at the same time, we can say that management is like the root of a tree and organization is like the leaves of a tree. It is difficult to expect the prosperous leaves on the tree without cultivating

the root of the tree in a good manner; so, if you want prosperous leaves on the tree, you must take good care of the root, even though you have had prosperous leaves before. Therefore, prosperous leaves must have a good root: that means good organization must have good management. If the management and organization in the previous discussion are combined together and are carefully carried out, we think it will produce a very much higher efficiency.



### Choice of Location for a Naval Shipyard

During the past few years American navy yards have been given more than usual attention. This attention has been chiefly directed towards management and organization but failed to give attention to the selection of location of naval shipyard from strategic point of view. This is because America does not worry about any attack on account of the fact that she has a powerful army, navy and air force. This recent world war teaches us that, if we want to establish any kind of industry, we must give consideration carefully from every point of view. The most important factor, as Professor Manning and Professor Smith always say, is strategic. Especially in China for an industry like a naval shipyard we must consider that. Recently strategic reasons have added force to economic ones, and we now see that we must have at least one great yard where the entire fleet can be repaired and supplied in time of war. It cannot, in a war with a powerful nation, be divided. Therefore, at least one properly located naval shipyard must be adequate to quickly effect repairs and docking, and furnish supplies. In order to select an adequate location, the following principal factors must be considered:

1. Strategical position as regards defense.
2. The land required.
3. Hydrographic conditions.
4. Handling vessels.

5. Transportation.
6. Labor supply.
7. Material supply.
8. Cost.

The above eight elements are the major factors for determining the definite site for a naval shipyard. Now we are going to discuss them separately as follows:

1. Strategic Position as Regards Defense

No location for a naval shipyard is suitable which is not protected by permanent fortifications, especially in recent days, preferably those required for a defense of important harbors or cities, nor if in a location subject to attack from the sea without the previous capture of the permanent fortifications.

(a) Attack from land.

The location should be such as to be free from the danger of capture by land forces which might operate in the vicinity without the capture of the permanent fortifications.

(b) Attack from sea.

The location should be free from the danger of attack and capture by the forces from the sea.

(c) Attack from air.

From the recent reports we know that the destructive power of the atomic bomb is very great and that army planes are going to travel 1000 miles per hour. So

that nothing on land is free from air attack unless we have a powerful air force for defense. The farther away from the enemy the better.

(d) ~~Entrance~~ to harbor.

The fortified entrance of the harbor should not be so restricted as to make possible the closing of it, which might prevent the fleet entering or leaving the harbor though the permanent fortification might still be intact.

2. The Land Required

(a) The primary factor in determining the exact site is the area which should have the following considerations:

1. The availability of land to meet current requirements and future expansion needs.
2. For a naval shipyard an area of not less than 235 acres should be available; this does not include any water area and is sufficient only in case its arrangement is such as to permit its utilization to the best advantage.

(b) Foundation conditions

The soil should be of a character suitable for the construction of wharves, graving dry docks, basin dry docks, and buildings, and to furnish foundations for heavy machine tools. While these structures and machines can be installed in any reasonable locations, the conditions of soil will influence to a considerable extent the total cost of constructing a plant.

(c) Water Front

As the necessary length of berthing space can be obtained satisfactorily only by the use of piers, it is very desirable that the water front line should be a straight line. The arrangement most to be avoided is a concave water front, on account of the difficulty of avoiding interference between dry docks and piers and vessels berthing and docking. If a water front other than a straight line or a slightly convex line is accepted, a considerable increase in length will probably be necessary.

(d) Topography

An elevation of approximately five feet above extreme high water at the water front with a level or slightly increasing elevation from the water front is the most desirable.

3. Hydrographic Conditions

(a) Depth to sea

The controlling depth to the sea should be, if practicable, forty-five feet at mean low water; this would permit any vessel to reach the yard at any time. Even the Queen Mary could get in the yard. Thirty-five feet would appear to be the minimum that can be considered for a main navy yard. Where there is considerable rise and fall of the tide the above figures may be considered

with reference to mean high water, though the restriction of handling of vessels to and from the yard to certain periods of the tide is very undesirable, especially if the yard is at a distance from the sea.

(b) Depth at yard

The water at the yard, including the entrance to the docks, the berthing spaces, and anchorages, should have a minimum depth at low water of not less than thirty-five feet. It is very desirable that this depth should be not less than forty feet, if obtainable, forty-five feet, this being based on the fact that vessels of approximately forty feet total draft could be accommodated.

(c) Tides and currents

At the yard itself a reasonable rise and fall of tide is not objectionable, though tides of not over six feet are preferable. A swift current is very undesirable on account of the difficulty of handling vessels to and from the yard and in docking, and the danger incident to such handling. This is of especial importance if the water basin in front of the yard is restricted.

(d) Berthing

A total berthing space should be provided having a length of approximately 20,000 linear feet, preferably provided with a number of parallel piers of a length not less than 1,100 feet in order to take vessels of the

maximum size, not only for battleships of the United States Iowa class, 880 feet, but also for the biggest transports like the Queen Mary and Normandie, without projecting beyond the end of the piers, and so as to obtain the necessary berthing space without the distance from the main shops becoming too great.

(e) Dredging

The original dredging necessary to obtain the prescribed depth is a matter affecting the cost of constructing the naval shipyard, and the amount of annual dredging to maintain these depths is an operating expense that will largely affect the relative merits of different sites.

(f) Avoidance of rough water

If it is practicable, the yard should be located on a harbor of relatively limited size in order to avoid rough or choppy water, which would interfere with the handling of barges, floats, and small crafts.

(g) Character of water

A location on sufficient fresh water, free from mud or silt, available for supplying the basins, or preferably where the density of the water is not great on account of the less rapid deterioration of the ship's

bottom. Freedom from teredoos and other water life which cause the deterioration and destruction of piling is an important asset to any locality.

(h) Commercial requirements for water developments

Any developments to channels, to the yard, and to anchorages, which may be reasonably required by commercial interests, can be counted on to be developed independently of naval appropriations; while these developments, if not required for commercial purposes, will undoubtedly have to be maintained out of naval appropriations.

4. Handling Vessels

(a) Fog and Ice

It is very important that free access to the yard should be available for vessels at all times. The access to the yard should be free from fogs which might endanger a vessel making a trip to the yard. The access to the yard should be free from ice. The presence of ice might force a vessel off its course or interfere with the handling of destroyers or other small crafts.

(b) Tides, currents and winds

Strong currents are the greatest difficulty in handling vessels at a yard. Excessive currents are an important consideration not only in the immediate vicinity of the yard but may be a source of danger to vessels

passing to and from the sea. The frequency of high winds may also influence the selection of a site.

(c) Interference by commercial vessels and anchoring

The channel to the yard should be free from interference by commercial vessels and anchoring, especially if the waters are restricted.

The anchorage around the yard should be sufficient and as near as practicable to the yard site.

5. Transportation

The problem of transportation is very important to the naval shipyard, not only for the supply of materials but also for the convenience of labor.

(a) From land

It is better for a shipyard to be close to the railway, at least not too far from the railway, for the convenience of input and output of materials.

(b) From the sea

It should be as near the sea as possible in order to get supplies from outside the country, especially in China. During the first couple of years we have to get the greater part of the materials from foreign countries; so, for the convenience of shipping, the yard should be as close to the sea as possible. From the defense point of view, it is better close to the sea in order to get rapid repairs during the war.



## (c) From the air

This is not important from the heavy industry point of view, but it is important from the defense point of view, so it is better as near the airport as possible.

6. Labor Supply

Labor supply is one of the most important elements in the location of a shipyard which depends on the following conditions:

## (a) The possibility of obtaining a sufficient force

This is dependent largely on the location of similar industrial concerns in the vicinity and on the living conditions in proximity to the yard.

## (b) The prevailing rates of pay

Living conditions are influenced to a considerable extent by the cost of living and its relation to the prevailing rates of pay.

## (c) Any locality which has abnormally high wages or restricted or unsatisfactory working conditions due to organizations or other special conditions becomes relatively unsuited for the location of a navy yard.

7. Material Supply

The material supply is one of the most important elements in the location of a naval shipyard. The ability to

perform work promptly is influenced to the greatest extent by the available material market. The material supply will depend largely on the following conditions:

(a) Transportation

It has been discussed in the previous section which is one of the important elements for the material supply. It is advantageous to be able to get different kinds of material from various ports or from foreign countries.

(b) Method of delivery

A direct rail connection to the yard by which standard cars can be handled to facilitate shipment is very important. The handling of material by lighters causes delays, rehandling and increased costs.

(c) Freight rates

The freight rates from the main centers of production of the materials used in shipbuilding and ship repairs play an important part in the cost of work. The number of railroad lines and the possibility of water shipments have an important bearing on the freight rates and ability to receive material.

## 8. Cost

Cost is of secondary importance from the military necessities point of view.

It is a very difficult problem to select a proper site for a naval shipyard due to the preceding conditions. It was desired to obtain a location in the south or north China coast near a big city like Canton or Tientsin. China has several good harbors along the Pacific coast, but we cannot use them on account of the condition as regards defense. In southern China, the harbors are too close to the British Far East naval base - Hongkong. In northern China, the harbors like Chinwangtao, Tsingtao, are too close to that Chinese territory which Russia claims as her spoil - Port Arthur. On account of these reasons, we finally decided that the best location is right at the middle of the China coast. It is so called Nimrod Sound. The Chinese name is Siangshan Kiang. In selecting the site in Nimrod Sound, which is about eighty-five miles from Ningpo, the nearest seaport and one hundred thirty-six miles from Shanghai, the items considered in the selection of this spot may be summarized as follows:

### 1. Strategical Position as Regards Defense

As regards strategical position, it is easy to defend against sea attack, as compared with other harbors along the China coast; and, furthermore, Nimrod Sound is

always likely to be incomparably the best defended port on the coast because of its great interests and the character of its entrance. Several channels are available for ships going in and out. There are numerous islands at the outside of the entrance as a shelter for the harbor. A navy yard, located at the place indicated in the accompanying drawing, which is far away from the sea is far more secure against a landing force than any location near Shanghai or Canton. As against air raid, its security is practically absolute.

## 2. The Land Required

Regarding land, it seems to us there should be no question at all, because this region has ample space available not only for building a naval shipyard but also for a big naval base.

The soil is suitable for the construction of wharves, docks, graving dry docks, and buildings. It has a wide range and straight line of water front which is quite enough for the piers to be built. The elevation is more than five feet above extreme high water at water front.

## 3. Hydrographic Conditions

The controlling depth to the sea is more than forty-five feet at mean low water, so even the biggest ship in the world could reach the yard at any time. The depth of water at the yard, including the entrance to the docks, the berthing spaces and anchorages, has a minimum value at low water of more than 35 feet.

The tidal current sets into Nimrod Sound from a few minutes after low water until a few minutes after high water; the outgoing current runs from a few minutes after high water until a few minutes after low water. During spring tides, the maximum current at the entrance is three knots; at the anchorage north of Eel Islet, the maximum rate is four knots.

The total berthing space has sufficient length for the needs of a big naval shipyard.

It is necessary to dredge along the side in order to meet the naval shipyard needs. Annual dredging to maintain a sufficient depth is not required because it has a good land condition.

There is no rough or choppy water around the yard, so that the handling of barges, floats and small craft is easy.

It has sufficient fresh water available for supplying the basins (if yard is built), the people's needs, and all other purposes. The waters are free from teredoes and other marine life which cause the deterioration and destruction of piling.

The harbor is so big that it can be used not only for building a big naval base and big naval shipyard but also for commercial requirements.

#### 4. Handling Vessels

As regards handling vessels and accessibility under all conditions of fog, ice, tide, wind and temperature, the access to the yard is quite free of drifting ice. In foggy weather, Nimrod Sound is much easier and safer to enter. The low water depth in the entrance channels of Nimrod Sound has, for thirty years, been maintained at ten or thirteen feet greater than deep-load draught of the heaviest battleships. The margin of depth is sufficient to take care of any probable draught of a battleship due to injury. The depth at all points from the entrance to the harbor to far above the suggested location of the yard is considerably greater than in the channels. The only dredging necessary would be in and near the yard wharves and piers. The suggested location of the yard and the arrangement of piers are such as to render access particularly easy. The currents in this locality are very much less than above or below. Inside the harbor there is sufficient space not only for big navy anchorage but also for commercial vessels anchorage.

#### 5. Transportation

The yard is about eighty-five miles from Ningpo, the nearest seaport, and one hundred and thirty-six miles from Shanghai, the Chinese New York, and is one of the biggest cities in the world. There is a railway from Shanghai to Ningpo, and a highway from Ningpo to Nimrod Sound. The

harbor is accessible to every form of vessel or barge and is no problem on transportation from sea. This area does not have an airport, but it will be easy to build one. At the same time, the yard is close to the airport at Ningpo; from the yard to Ningpo is only eighty-five miles.

#### 6. Labor Supply

Labor supply for the yard is no problem at all, because labor conditions in China are quite different from those in America. Labor in China is cheaper and easier to get than in the United States. The only one problem is that they need special training in order to meet the needs. So we have a chapter especially dealing with various kinds of worker training in order to get the efficient and skillful labor to meet the yard needs, not only for building new ships and repair work in peace time, but also to prepare for war-time use. The immediate locality has now no industrial population, but a plant of this size will have no difficulty in attracting the required labor from surrounding cities.

#### 7. Material Supply

As regards material supply, Shanghai is a great center of supply of materials and is incomparably superior to all other ports, as it is by far the greatest center of supply of materials that exists in China. Articles of ordinary commercial design and composition can be obtained in a few hours. At the same time, Ningpo is one of the great

seaports in China and is a source of material supply. Articles of ordinary commercial design and composition can be obtained from there, but special articles we have to get from Shanghai or some other place or foreign country. We cannot solve the difficult problem of material supply until all kinds of industries and transportation facilities have been fully developed in China.

#### 8. Cost

As regards cost, it would be very expensive because all kinds of machines and materials would have to be purchased from foreign countries. This problem cannot be solved until we have our own industries developing. However, from a military necessities point of view, cost is not as important as other conditions. Therefore, if we want to have a naval shipyard, we do not care how much it does cost.

From the above discussions, we realize that the best locality for naval shipyard is Nimrod Sound.



General Arrangement of the Naval Shipyard

The accompanying sketch, Plate II, shows the general arrangement of shops, piers, docks, and the material flow of the proposed naval shipyard. Some details have been shown on various shop arrangements. General characteristics shown are planned to meet the broadest requirements possible and still maintain a high efficiency.

It will be noted that the proposed naval shipyard is placed where its inner end abuts land contiguous to the main railways and highways, and its outer end reaches deep water. The cost of transporting supplies of all kinds is therefore reduced to a minimum. The yard will be located where the tidal current is always weak so that it will be easy of access. The proposed naval shipyard will cover 16,000,000 sq. ft. equal to 367.3 acres of land. The land of this proposed shipyard will be very flexible; it can be used as a naval base and expanded to meet a huge production program in the future as shown in the general arrangement.

The shipways, shipbuilding basin, graving dry dock and marine railways are from east to the west.

There are five main piers which will be laid out parallel one to another all of 1000 feet length and 80 feet width. These piers will berth ten battleships or other war vessels of the largest size. Between pier

No. 1 and pier No. 2 have 400 feet. The rest have 250 feet from pier to pier.

The layout has been carefully studied and we believe it to be best for wharfage space, fitting out, repair, convenience of operation and general efficiency.

There are two shipways of 900 feet length and 130 feet width, six basins, each of 470 feet length and 80 feet width, which will be laid side by side and parallel one to another as shown in the general arrangement.

The graving dry dock of 1000 feet length and 145 feet width will be located next to the basins. This graving dry dock may not be built immediately because of the large cost and China does not need it right away because no battleships, carriers or large liners exist in China at the present time.

One floating dry dock will be used for 2000 tons *destroyers* or small naval vessels. It will be located left of the graving dry dock and parallel to each other as shown in the general arrangement.

There are two marine railways for the use of 1000 ton ships. They are located next to the floating dry dock.

Parking space -- one of the most important things we have to consider in the modern shipyard is parking space. The space will be large enough at a convenient place in order to meet employees needs as shown in the general arrangement.

With regard to the buildings, etc., necessary for a naval shipyard usually include the following:

1. Buildings for offices
2. Fabricating shop
3. Mold loft
4. Machine shop
5. Boiler shop
6. Blacksmith shop
7. Pipe shop
8. Galvanizing shop
9. Joiner shop, carpenter shop, pattern shop, wood mill
10. Sheet metal shop
11. Coppersmith shop
12. Electrical shop
13. Paint shop
14. Foundry shop
15. Turret shop
16. Store house
17. Powerhouse
18. Apprentice school
19. Cafeteria
20. Miscellaneous small shops and buildings to cover  
such needs as timekeepers, toilets, etc.

### 1. Building for Offices

This building is the headquarters of the yard. It will be located at the entrance of the yard and contains the executive offices, engineering, estimating, and drawing rooms, blueprint room and confidential storage vault.

### 2. Fabricating Shop

Almost without exception, the shop that is closest to the buildingway is the plate shop, sometimes called fabricating shop or steel mill. Here the molds or templates that have been turned out by the mold loft are laid out on the actual steel, and the first part of the ship itself, the hull structure is made and shaped on face plates and forms. Lightening holes and such are burned out by hand or by automatic cutting machines, which permit duplicate burning of many similar shapes at the same time. From the plate shop, the material goes either to assembly plates or the ways, depending upon the yard set-up.

Use of welding has permitted huge sections of the ship's structure to be assembled away from the building ways. Use of machine welding has given birth to methods of erection whereby the structure is assembled upside down. The only limit to subassembly is the lifting capacity of the derricks and cranes in the yard, and the awkwardness of the size and shape of the subassembly being built. Thus we find that most yards limit themselves to sections of double bottoms, forepeak and afterpeak sections, and

small superstructures, although there are yards where the whole ship (not too large of course) is built upside down and turned over in specially built cradles or rockers and other yards where the structure is erected in pancake sections which are moved to the building ways for final assembly. This method of subassembly sometimes permits other departments to work on the subassemblies and thus expedite the completion of the ship.

Pipefitters thread pipe through the lightening holes of floors and intercostals while the double bottom is lying on its top. Insulation is secured to bulkheads lying on their sides, stacks are completed with interior bulkheads, gratings and ladders, pipes and whistles before installation on the ship, huge manifolds and pipe sections are assembled for installation as a complete unit, stern tubes with bushing and linings are finished; lineshafting is completely aligned and bolts fitted before installation in the ship; vent ducts are made up ready for installation; masts are completed with electric light fixtures, wiring, ladders, boom fittings, and everything except the boom for installation as a complete unit. Rudders are completed out in a field and are just lifted into place; main and auxiliary machinery foundations are completed elsewhere and lifted and installed in the ship; built-in furniture is completed elsewhere and just fitted and secured in the ship, as are galley dressers and tables and other items of this type.

### 3. Mold Loft

The mold loft is a building or shed of great horizontal extent which permits of its having a large continuous floor of sufficient size to have drawn on it the lines of the ship to full scale. The plans of a ship to be built are furnished to the mold loft by the drafting room; and from these plans the workers in the mold loft called loftsmen, lay down and pair up, to full scale, the lines of the ship and make templates for laying out the material for the hull. Templates are thin wood or paper patterns which show the size, shape, locations and size of rivet holes or welding instructions and other particulars of parts to which they apply. The mold loft should be as close to the fabricating shop as possible on account of their close relationship. It will be located on the second floor of the fabricating shop and cover 80,000 square feet of space.

### 4. Machine Shop

After the plate assemblies, the next biggest items that go aboard the naval vessels under construction are main propulsion units, boilers, condensers, guns and turrets and other heat exchange units. In some yards, the machine shop is close to the building ways and in others close to the outfitting ways. Perhaps the ideal place for the machine shop would be, because of the many heavy lifts made, adjacent to the fabricating shop and as close as

possible to the building ways.

In addition to the heavy machining in the machine shop, there are numerous small items which are made in the shop. The output of the brass gallery, when valve stems and parts, footlight frames, bushings, and numerous other small items of non-ferrous material are machined to be delivered to the ships and shops. If the machine shop is large, it not only machines shafting, stern tubes, turbine rotor and engine cylinders, but cuts gears, faces and shapes propellers, makes and installs blading in turbine rotors, faces and bores huge hull casting such as stern frames, rudder frames and stocks.

#### 5. Boiler Shop

The boiler shop fabricates boilers in the large yards, builds uptakes and smokestack and makes pressure vessels and heat-exchange units of all sorts. Incidentally, the uses to which the various shops are put today depend not so much upon strict adherence to what usual practice, but to what purpose the equipment and machines in the shops can be put when what would be normal products of the shop are bought outside the yard.

#### 6. Blacksmith Shop

In the blacksmith shop, we find finished forgings being made for direct use on the ship and rough forgings being made both for the plate shop and machine

shop to finish. This shop, therefore, should be located in close proximity to both the plate shop and the machine shop.

#### 7. Pipe Shop

The pipe shop frequently not only handles the installation of the piping on the ship from deck scuppers to main steam lines, but also prefabricates as much as possible of it in the shop in ~~each~~ fashion as cutting, threading, bending, flanging, and in some instances by the use of such machines as the ~~van~~ storing does a lot of work that would otherwise have to be done outside the yard. In the pipe shop one also sees welding of pipe, manufacturing of flanges, and hydrostatic testing of individual pipe lines. This shop will be located inside the fabricating shop.

#### 8. Galvanizing Shop

Frequently, the galvanizing shop, regardless of their size, are part of the fabricating shop. It is here that bare pipe, plate, etc., is galvanized for services so specified, and many other items are likewise treated, depending solely upon the size of the pots. We put this shop separate from the fabricating shop, but it should be as close to the fabricating shop as possible.

#### 9. Joiner Shop and Carpenter Shop

In these days of limited use of wood aboard ship, much of the work that formerly was done by the



carpenter and joiner shop is now done by the sheet metal shop. The joiners themselves have had to become familiar with the uses of sheet metal, composition bulkheading, light angles and channels, etc., so that many of them are now capable of following two trades instead of one. The shop has become limited in its output to practically a few wooden items, such as deck planking, cargo battens (none in warships) and wooden ladders. For the purpose of centralizing so we put these two shops within the woodworking building.

#### 10. Sheet Metal Shop

The sheet metal shop contains much of the equipment that one sees in steel mills except that all of it is much lighter, since the rolling, bending, flanging and cutting is on light sheets and not steel plate. Cowls, ducts, lockers, dressers, tables, work benches, bins, tanks, sheet metal partitions and light bulkheads form the output of most shops.

#### 11. Copper Shop

The copper shop sometimes attached to the sheet metal shop and sometimes to the pipe shop, is responsible for the making of large copper pipes, installing the flanges thereon, and such other copper equipment as may be used on the ship, as well as the installation of large and small copper pipe on the ship.

### 12. Electrical Shop

The electrical shop has its ship installation work broadly divided into three parts: power, lighting, and intercommunication wiring. Electrical shops in the larger yards are arranged so that much setting up can be done in the shop to permit rapid and easy installation of cables, fittings and fixtures in the ship. The shop usually has facilities for overhaul and repair of small sized motors, armatures and the manufacture of clips, brackets and other small items required in electrical installations thus relieving both the machine shop and sheet metal shop of some work, so it is as close as possible to both the machine shop and sheet metal shop. In the proposed naval shipyard this shop will be located inside the machinery shop.

### 13. Paint Shop and Rigging Shop

The paint shop is another shop which has to wait on other shops before most of its outside work can be done. Outside hull painting, finished painting in quarters and accommodations and machinery spaces and all sorts of coating from ordinary red-leading and color painting to cement washes and bitumastic coatings under insulation fall within the province of this shop. The rigging shop and painting shop will be located close to the piers, marine railways and graving dock.

14. Foundry Shop

The foundry is a shop which does the casting works not only for the use of machinery but also for the part of hull structure. This shop will be located close to both fabricating shop and machine shop.

15. Turret Shop

The turret shop is a shop which does all the work of guns, assembling and mountings. This shop does not have a special relation to other shop except electrical shop and outfitting shops. It will be located as shown in the general arrangement.

16. Storehouse

Storehouses are necessary in considerable variety and should be located conveniently to the shops requiring the largest quantities of the materials stored in each.

17. Powerhouse

The powerhouse will be placed closed to the waterfront so that fuel can be delivered directly into the bunkers of the boiler plant while ashes can be ejected into the dump scows. It is planned to use coal because coal is cheaper than oil in China.

18. Apprentice School

There are three school buildings in the yard. One building is known as the training center, and the

other two houses the welding school and the chipping and grinding school. In the training center, a two-story structure, are rows of shops and classrooms where trainees get their first instruction and experience in mold loft, fabrication, assembly work, blueprint reading and hand and machine burning. On the first floor is a miniature mold loft and miniature ways, forty hand burning stations and six burning stations. On the second floor are four large classrooms and an auditorium, seating 250 persons, where moving pictures are shown.

At the welding school as many as 130 men and women can, if necessary, be trained at one time to weld. In this building are 100 electric welding stations, 14 electric pipe-welding stations and acetylene welding stations. The school is also equipped with testing machinery and the machine tool equipment for preparing the plates and pipes for testing.

In the chipping and grinding school men are instructed in the use of air chipping hammer, air grinding and the various shaped chisels for cutting purposes. The school building contains 25 chipping stations and 5 grinding stations.

These three buildings will be located close to the main building.

### 19. Cafeteria

A cafeteria is very necessary in a modern shipyard in order to solve lunch problems. It will be located as shown in the general arrangement.

### 20. Miscellaneous Small Shops and Buildings

These shops and buildings to cover such needs as timekeepers, toilets, etc. will not be described here.

### Flow of Materials

This is the most important factor in order to increase the production. There are two more functions that are part of each shipyard -- one is the receiving and storing of material and the other is transportation of material from the storerooms, warehouses and the shops to the ships.

Particularly today, when so many subcontractors are involved in order to keep up the current schedule, it becomes essential, when ordering material, to time its delivery in such fashion that the shipyard does not become a huge warehouse. No shipyard can afford to have too many buildings serving no purpose other than as storage space. Neither can a shipyard afford to wait until its store of a particular material is exhausted before replenishing it. Supplies must be kept on hand so that at no time will a group of men from any shop be idle because of the lack of materials. There must be a

constant flow of the essential materials into the yard in such a fashion that the supply in the storerooms is practically constant and always just ahead of the demand.

Material shipped into a yard must be checked, stowed and marked for easy identification so that when the time comes for its use, it is readily available. Then the material has to be moved either to a shop for work to be done on it prior to its going aboard the ship or it is moved directly to the ship either at the launching way or at the basin.

The methods of transportation within the yard vary greatly. One sees traveling cranes in the shops capable of lifting all sorts of weights depending upon the shop. In the fabricating shop and the machine shop railway tracks are usually run so that direct transfer can be made from the traveling cranes to railroad cars, which in turn are rolled down to the ways in order for the way cranes to place them aboard the ship. There is also much rolling equipment of all sorts in the various yards varying from ordinary truck and tractors to flat cars, gondolas, and boxcars and railroad derricks both of steam and Diesel-driven types. In the underdeveloped condition of China, she has to use all facilities she had, However, we have to standardize all equipment in order to keep the work in higher efficiency.

The gantry crane is the lifting equipment necessary to place material and equipment aboard the ship under construction. Where the building ways are parallel to each other, one usually sees a type of crane which permits lifting to either side, so that two ships are served by the same crane. Thirty gantry cranes are 48 feet high from tower track to roller path, and boast a 25-ton lifting capacity within a radius of 85 feet. Three are 70 feet high with a capacity of 25-tons within a radius of 85 feet. All are of the portable type permitting the passage of standard railroad equipment and locomotive cranes underneath.

Cranes

10	25-ton hoist gantry cranes	piers
7	25-ton hoist gantry cranes	basins
3	25-ton hoist gantry cranes	graving dry dock
3	25-ton hoist gantry cranes	marine railways

Bridge Cranes

4	25-ton bridge cranes	shipways
2	200-ton bridge cranes	shipways
2	10-ton bridge cranes	

Locomotive Cranes

2	15-ton steam hoist locomotive crane
2	25-ton steam hoist locomotive crane

Mobile Cranes

3	10-ton truck cranes
6	15-ton truck cranes



### Detailed Layout of Shops

In this section we wish to lay out the important shops by the use of sketches. The reason for doing so is that sketches in many cases are much clearer than descriptions in words.

Word descriptions will only be found on matters which cannot be expressed by the sketches.

Each building will be taken as a unit of discussion instead of each shop.

Flow of materials has been discussed in the general layout, so we do not repeat it here.

Power used in this new yard will be mainly steam or electricity. All power will be supplied by the yard's own power plant.

Machinery used in each shop can be found in the equipment list which will be attached to each plate.

If no special machine or special arrangement requires attention called to it, there will be no description necessary.

Two tugs and four work boats are considered as the minimum requirement for adequate service.

Fire fighting equipment, hospital and first aid station will not be discussed, because there is no doubt about their necessity, and such equipment is new to the authors.

General Offices

The general offices are centrally situated at the main entrance. It is consist of four divisions and seven departments. The four divisions are Management Planning and Review Division, Industrial Relations Division, Electronics Division, and Ordnance Division; the seven departments are Planning Department, Production Department, Public Works Department, Supply Department, Fiscal Department, Medical Department, and Administrative Department; and all the other offices in connection with the bussiness and management of yard, with addition of a blue print room. It will be a two story stone building which occupies a space of 60,000 square feet. The second floor will be occupied by the two designing offices ( hull and engine ), the blue print room ( There are three sets of blue print machines, one set of two sea bees and photostatic equipment and dark room ), and the confidential materials and files keeping room. The Commander of the yard and his executive officers and the four divisions , seven departments will occupy the main floor. A bussiness meeting hall will be also located on the main floor.

Crane Service

Crane service for building slips and shipbuilding basins. There is perhaps more room for individual preference in the selection of the type of cranes to be used for handling material at the building slips than in any other feature of a shipbuilding yard. This freedom of choice has been fully exercised in the extension of the older yards which we have visited. The available types fall into three general classes:

1. Fixed, rotating cranes. Those which have no longitudinal travel and deliver their material at the desired point by rotating, and either by trolleying or luffing.
2. Traveling, traversing cranes. Those which have both a longitudinal travel and a cross travel.
3. Traveling, rotating cranes. Those which have a longitudinal travel and a rotating motion.

The fixed and rotating cranes involve a great variety of types, which include the hammerhead type and the luffing boom type, both rotating on relatively high towers, the staid type supported on the ground, and derricks placed on towers such as are in general use in building construction. In general, the most suitable field for this class of crane is the slip for smaller ships, involving the handling of small weights, as the handling of relatively heavy weights

means the providing of a large capacity for most or all of the cranes. The chief objection to them lies in their relatively small capacity and short reach, the necessity for large numbers of operators, the difficulty in delivering and storing material within reach of the crane to be used in placing it on board the vessel, and that they can not be moved to the places where needed.

The traveling, traversing crane. In this class is included the cantilever type, which was in favor in the early days of large shipbuilding but which has now generally been abandoned, at least as far as new installations as far back as twenty years ago are concerned; and the bridge type which probably gives the most effective service, though generally at the highest cost. Cantilever cranes are not a desirable type on account of the limited number of hooks that can be made available, the combination tending to limit the speed of erection. Bridge cranes permit the handling of the heaviest weights and provide an installation that most nearly approximates shop conditions, as far as ability to deliver material at all points is concerned. The principal argument against this type is its initial cost, and that it is limited to one slip.

The traveling rotating types included the hammer-head and luffing types of cranes operating on wide-gauge trucks on the ground, and also electric and steam locomotive cranes. The cost of these types is less than bridge cranes

and also less than the fixed, rotating cranes (due to less cranes being needed for same performance). Some very rapid construction in the last few years has been done, utilizing this class of crane and it has proved to be very satisfactory. In general, this class of crane appears to the best advantage in building vessels of moderate size, where the individual weights to be handled are not large.

Crane service for the shop leaves a rather narrow field of choice of cranes. So, in conformity with usual practice, we use the bridge crane for heavier loads and the jib crane for light ones.

Crane service for the fitting out piers. In this work the cranes which can be used in the building slip can also be applied here, with the addition of floating cranes. Floating cranes will not be considered here due to their high cost that is beyond the amount we can afford.

To sum up the foregoing discussion, we are not in favor of the fixed, rotating cranes. The other cranes will be adopted whenever it appears best to do so.

Fabricating Shop and Mold Loft

The activities of the yard most directly connected with the building of ships are housed in this shop. The fabricating shop in this yard consists of three bays, one for plate works, one for angle or shapes, and the other for pipes. As is the common practice, a partial second floor is provided for the mold loft. The mold loft has been discussed in general arrangement, so we will not repeat it here. A pipe shop usually can be found in the machine shop; but we consider it will be better to put it inside the fabricating shop, so as to have a shorter transportation route for the pipes after being bended or fabricated.

Continuous flow of work is to be obtained by the raw material entering at the end of the shop nearest to the storage yard, going first to the laying off space, then to the fabricating area, and thence to the assembly space, and out at the door nearest to the building slip or shipbuilding basin by means of both standard gauge railroad trucks, and electric traveling cranes which travel on the wide gauge tracks. With this arrangement, a piece of material may be delivered from any point in the shop to any ship under construction with a maximum of freedom and minimum of time.

The size of plates used in ship construction has grown steadily, and an effort will be made in laying out this shop to adopt the maximum size that plates are likely to

reach (a plate 40 feet long by 9 feet wide, by  $2\frac{1}{2}$  inches thick) and to provide machine tools and arrangement so that any size up to this point may be taken care of without any difficulties.

Fabricating Shop Equipment List

Key No	Name	Size
001 to 020	Lay-off Table	25' x 9'
021 to 022	Lay-off Table	10' x 5'
023 to 024	Threading Machine	$\frac{1}{2}$ " to 2"
025	Hydraulic Bending Machine	2 $\frac{1}{2}$ " to 6" pipe
026 to 027	Hydraulic Bending Machine	$\frac{1}{2}$ " to 2" pipe
028 to 030	Threading Machine	2 $\frac{1}{2}$ " to 8" pipe
031 to 033	Drill Press	3" hole
034	Drill	10"
035 to 036	Gringer	12"
037 to 038	Power Band Saw	7" x 7"
039 to 040	Hydraulic Pipe Bender	3/8 " to 1 $\frac{1}{2}$ "
041	Stone Cut-off Saw	20"
042	Hydraulic Press	50 ton
043	Duplex Fuel Oil Pump	5" x 6" 100 gal/min.
044	Oven Furnace	7' x 9'
045 to 063	Beamograpes	
064 to 067	Angle & Bar Shear	10 sq, in.
068	Metal Cutter	7" x 7"
069	Angle Shear	6" x 6" x $\frac{3}{4}$ "
070 071	Shape Punch	10 sq. in.
072 to 074	Bending Block	17' x 17'
075 to 077	Electrical Furnace	5' x 9' x 4'
078	Cold Press	10" Channel
079	Hydraulic Joggler	250 ton.



Fabricating Shop Equipment List

Key No	Name	Size
080	Angle Beveler	10" Channel
081 to 083	Spot Welder	250 KVA
084 to 087	Vertical Punch With Feed Table	36" Throat
088 to 091	Vertical Punch With Feed Table	48" "
092 to 093	Vertical Punch With Feed Table	24" "
094 to 097	Shear	36" "
098 to 101	Shear	48" "
102 to 106	Radial Countersink	16' Swing
107 to 109	Electrical Plate Furnace	10' x 24' x 4'
110 to 111	Bending Rolls	9' x $\frac{3}{4}$ " Plate
112 to 115	Bending Rolls	Top Roll 20" dia.
116	Hydraulic Keel Bender	500 ton
117 to 120	Hydraulic Press	300 ton.
121 to 122	Drill Grinder	20" 2-spindle
123	Scarphing Machine	16' Plate
124 to 134	Pneumatic Riveter	36"
135 to 136	Friction Saw	54"
137 to 141	Plate Planer	54" Plate
142 to 143	Power Hack Saw	12"
144	Rotary Hack Saw	48"
145 to 149	Gate Shear	$\frac{3}{4}$ " Plate
150 to 154	Spot Welder	
155 to 159	Erecting Platen	150' x 100'
160 to 169	Welding Machine	

Mold Loft Equipment List

Key No	Name	Size
01 to 02	Band Saws	40" Swing
03 to 04	Planers	36" x 10"
05	Switchboard Panel	20'
06 to 07	Circular Saws	12"
08 to 09	Jointers	6"
10 to 11	Radial Drill Presses	36"
12	Line Table	8' x 10'
13	Line Table	8' x 20'
14	Grindstone	18" x 2½"
15 to 18	Work Benches	8' x 2'
19 to 21	Work Table	12' x 4'
22 to 23	Portable Racks	6' x 3'
25	Tool Locker	28' x 2'
26	Tool Locker	6' x 6'
27	Tool Locker	16' x 3'

Fabricating Shop Crane List

No.	Type	Capacity
6	Bridge ( Electrical)	75 ton.

Machine Shop

Provision must be made in the machine shop for handling forgings and castings of the largest size. No attempt has been made to discuss all the equipment in great detail. As stated before, special machines will be kept to a minimum in this yard, and only these special machines and the extra size machines will be brought out in these paragraphs. Only the main machinery will be indicated in the plates and equipment lists which will follow. The machine shop in this new yard consists of four main bays and a small bay. The size of each bay will be found in plates. All machines will be driven by separate motors, and will be so arranged that the materials will take the shortest route from beginning to end. (It should be noticed that this principle will be followed in all shops.) The four main bays will be machine making, gear hobbing, shaft turning and propeller making bays. The small one will be divided into three parts, one for small machine work, one for tool making department, and the other for electrical repair shop; and will also be provided with an intermediate floor, forming a gallery for other light tools.

Machine making bay: Machine making bay will be served by two 75-ton bridge cranes with 90-foot spans.

Six heavy duty lathes, taking up pieces of 150 inches in diameter and 26 feet long.

Six close side planers, taking pieces of 12 feet wide, 10 feet high, and 30 feet long.

Two vertical boring mills of 12 feet.

Above are the main tools used in the machine making bay. The less important machines will be listed later as stated before.

Gear hobbing bay: Two rooms of 50 feet by 50 feet and 40 feet high will be provided for reduction gear hobbing. These two rooms will be isolated from the other parts of the building. Thus, these rooms can be kept at a constant temperature, so that the changing temperature of the weather will not affect the hobbing of the gears. Two independent power sources will be introduced to each hobbing machine, so that in no case the hobbing of the gear will be interrupted by interruption of power supply. Thus the gear will not be spoiled during hobbing by an interruption of power. The top and one side of these rooms can be removed when the gears are being moved in or out of the rooms. This will enable the cranes in the machine shop to be used without providing any extra cranes. The hobbing machines in these rooms will be able to mill gears up to 14 feet in diameter.

Propeller Making Bay: Propellers will be cast in this very yard. The method to be used to manufacture propellers in this yard will be the method which Mr. S. H. Towne described in his paper in "The Transactions of The

Society of Naval Architects and Marine Engineers", Volume 51 from page 39 to 50; that is, to cast the propellers in cement molds, using a single-bladed metal pattern of such accuracy as to insure a propeller casting that would not need to have machined surfaces. This method will be adopted since it has been proved that material can be saved by this method and no costly machinery will be required. So the equipment used in this bay will be according to the requirements stated in Mr. Towne's paper.

Shaft Making Bay: Four shaft turning lathes, taking shafts up to 40 inches in diameter, and 35 feet long. A dynamical balancing machine having the same capacity will be installed to balance these shafts.

Machine Shop Equipment List

Key No	Name	Size
001 to 006	Heavy Duty Engine Lathe	150" Swing 26'
007 to 012	Closed Side Planer	12' x 10' x 30'
013 to 014	Vertical Boring Mill	120" x 100"
015	Balancing Machine	140" Wheel
016	Engine Lathe	48" x 50'
017	Engine Lathe	48" x 21'
018 to 019	Engine Lathe	54" x 36'
020 to 023	Radial Drill	5'
024 to 025	Radial Drill	8'
026 to 028	Open Side Planer	60" x 60" x 18'
029 to 030	Vertical Boring & Taring Mill	72"
031 to 033	Horizontal Boring Mill	5'
034	Side Head Boring Mill	44" x 36"
035	Erecting Platen	28' x 108'
036 to 037	Convertiable Planer	96" x 120" x 26'
038	Face Plate	20' x 10'
039 to 040	Reduction Gear Making Machines	14' Gear dia.
041 to 050	Univ. Milling Machine	52 $\frac{3}{4}$ " x 10"
051 to 055	Univ. Milling Machine	78 $\frac{1}{2}$ " x 16"
056 to 065	Electrical Grinder	3 H.P. @
066 to 085	Air Chipping Harmmmer	3 H.P. @
086 to 087	Pitchometer	100" rad.
088	Dynamic Balancing Machine	100" Rad. Propeller
089	Propeller Hub Boring Machine	30" x 100"

Machine Shop Equipment List

Key No	Name	Size
090	Propeller Key Seating Machine	4" x 7" x 40"
091 to 094	Shaft Lathe	40" x 30'
095	Dynamic Balancing Machine	40" shaft
096 to 098	Lathe	14" x 3'
099 to 100	Power Hack Saw	4" x 4"
101 to 103	Lathe	10" x 30"
104	Twist Drill Grinder	4"
105 to 107	Tool Grinder ( Wet )	36" x 4"
108 to 109	Shaper	7"
110 to 112	Milling Machine	5"
113 to 114	Drill Press	20"
115 to 117	Electrical Furnace	4' x 5' x 1½'
118 to 119	Knife Grinder	2' x 2¼"
120 to 121	Tempering Plate	7' x 5'
122	Cooling Tank	4' Dia. x 3'
123 to 125	Drill Press	12"
126 to 128	Drill Press	28"
129 to 130	Coil Winding Machine	17" Winding Rotor
131	Insulation Shear	36"
132	Insulation Former	8"
133	Baking Oven	15' x 7'
134	Armature Growler	
135	Field Growler	
136 to 137	Lathe	10" x 6'

Machine Shop Equipment List

Key No	Name	Size
138 to 142	Bench Grinder	8"
143 to 144	Pedestal Heavy Duty Buffer	10"
145 to 146	Coil Winding Head	17" x 13"
147 to 148	Graphotype Embosser	1/6 H.P.
149 to 150	Pipe Threader	1/2" to 2" pipe
151 to 155	Vertical Boring Mill	53"
156 to 157	Face Plate	20' x 10'
158	Rolls for Lagging	6'-4"
159 to 161	Closed Side Planer	51" x 17'
162	Hydraulic Horizontal Press	150 ton.
163 to 165	Centering Machine	6" 2-spindle
166 to 168	Power Hack Saw	7" x 7"
169 to 172	Drill Press	36" Dia.
173 to 175	Arbor Press	7" x 6"
176	Freight Elevator	4 ton.
177 to 180	Erecting Platen	15' x 36'
181 to 183	Screw Cutting Engine Lathe	32" x 27'
184 to 185	Screw Cutting Engine Lathe	24" x 18'
186 to 187	Screw Cutting Engine Lathe	18" x 15'
188 to 190	Speed Lathe	12" x 6'
191	Key Seater	48"
192	Key Seat Milling Machine	48" x 3"
193 to 196	Double Head Shaper	26"
197 to 198	Crank Slotting Machine	12"
199 to 200	Crank Slotting Machine	24"
201 to 224	Revoling Tool Table	5' dia.



Machine Shop Equipment List

Key No	Name	Size
225 to 229	Wet Tool Table Grinder	24" x 2½"
230 to 233	Dry Tool Grinder	36" x 4"
234 to 235	Planer	36" x 36" x 12'
236 to 241	Planer	30" x 30" x 12'
242 to 243	Shaper	16"
244 to 245	Crank Shaper	24"
246 to 247	Crank Shaper	20"
248 to 250	Bolt Cutter	4"
251 to 252	Drill Press	26"
253 to 254	Drill Press	24"
255 to 256	Upright Drill Press	24"
257 to 258	Engine Lathe	54" x 10'
259	Engine Lathe	38" x 19'
260 to 261	Planer	24" x 24" x 8'
262 to 264	Screw Lathe	20" x 17'
265 to 268	Screw Lathe	16" x 18"
269 to 276	Engine Lathe	19" x 12'
277 to 280	Engine Lathe	18" x 8'
281 to 284	Engine Lathe	20" x 10'
285 to 289	Engine Lathe	20" x 14'
290 to 295	Engine Lathe	21" x 18'
296 to 297	Engine Lathe	21" x 12'
298 to 300	Turret Lathe	2" x 24"
301 to 302	Turret Lathe	2¼" x 28"

Machine Shop Equipment List

Key No	Name	Size
303 to 305	Turret Lathe	3 $\frac{1}{4}$ " x 29"
306 to 307	Tool Gringer	36" x 4"
308	Reaming Lathe	20" x 5'
309	Strap Polish Machine	4" 5 hp.

Machine Shop Crane List

No	Type	Capacity
9	Bridge	50 Ton.

Boiler Shop

This boiler shop is designed to build various types and various sizes of boilers for ships. The position assigned for each piece of equipment is according to the sequence of operations and its relation to other pieces of equipment. By doing this, an elimination of moving the materials forward and backward, and thereby making the best use of the equipment, is expected. For handling materials there are two long span and one short span bridge type cranes operated by electrical power, seven short span bridge type cranes operated by hand, and twelve jib cranes operated by hand. Standard gauge and narrow gauge railroad tracks are also installed for handling materials.

After completion each boiler will have a hydraulic test in the shop. Hence a water pump is provided for that purpose.

The office and the templet shop are located alongside of the boiler shop, so the disturbance from the noise of the hammers is much less.

BOILER SHOP - EQUIPMENT LIST

<u>Key No.</u>	<u>Name</u>	<u>Size</u>
1-2	Coal Forge	5' diameter
3-4	Bending Slabs	5' x 5'
5	Vertical Plate Rolls	1 3/4" Plate
6-7	Oil Furnace	1 Burner
8	Portable Hyd. Riveter	1 5/8" Rivets
9	Bending Rolls	8" dia. x 8'-0"
10	Anvil	3' x 2'
11	Radial Countersinking Mach.	15'-0" Rad.
12	Radial Drill	44" Rad.
13	Radial Drill	6'-0" Rad.
14	Shear	5/8" Plate
15	Drill Press	4'-6" Rad.
16	Punch	2" Hole
17	Radial Drill	12'-0" Rad.
18	Punch	1 1/2" Hole
19	Steel Pressure Blower	3.47 oz. per sq. in.
20	Plate Planer	16'-0" stroke
21	Drill Press	Dia. Work 12"
22	Comb. Punch and Shear	Shear 3/8"
23	D. C. Motor	75 H.P.
24	Oil Pump	
25	Pressure Oil Tank	2'-8" x 7'-0"
26	Double Grinder	16" x 2 1/2"

BOILER SHOP - EQUIPMENT LIST - continued

<u>Key No.</u>	<u>Name</u>	<u>Size</u>
27	Double Angle Shear	4" x 4" x 3/8"
28	Oil Furnace	1 Burner
29	Oil Furnace	7 Burners
30	Hyd. Riveter	1 5/8" Rivets
31-32	Coal Forges	5' dia.
33-34	Bending Slabs	5' x 5'
35	Hydraulic Press	120 tons
36	Shear	1 1/8" Plate
37	Flanging Clamp	12'-9" long
38	Hot Punch	15/16" Hole
39	Comb. Punch and Shear	1 5/8" Dia. Bolts
40	Motor	50 H.P.
41	Boiler Shell Drill	18' Dia. Boiler
42-44	Coal Forges	5' dia.
45	Anvil	3' x 2'
46-48	Bending Slabs	7' x 7'
49	Steam Hammer	250#-300#
50	Rivet and Bolt Mach.	1 1/4"
51	Rivet and Bolt Mach.	2"
52-53	Oil Furnaces	2 Burners
54	Rivet Rumbler	(hand tool)
55	Platform Scale	

BOILER SHOP - EQUIPMENT LIST - continued

<u>Key No.</u>	<u>Name</u>	<u>Size</u>
56	Steel Pressure Blower	3.47 oz. per sq. in.
57-58	Grinders	16" x 2 $\frac{1}{4}$ "
59	Bolt Cutter	1" to 2 $\frac{1}{2}$ "
60	Threading Machine	2"
61	Turret Lathe	2"
62	Engine Lathe	16" Swing
63	Drill Press	12" D. Plate
64	Power Hack Saw	5" x 6"
65	Shaper	6" Stroke
66	Work Bench	8' x 2'
67	Machine Lathe	20" Swing
68	Double Grinder	16" x 2 $\frac{1}{2}$ "
69	Windlass for Lifting Doors	5 H.P.
70	Air Tank	
71	Water Pump	1800 p.s.i.

BOILER SHOP - CRANE LIST

<u>Key No.</u>	<u>Type</u>	<u>Operation</u>	<u>No.</u>
200-201	3-ton Bridge	Hand	2
202-204	1½-ton Bridge	Hand	3
205-206	Jib	Hand	2
207	Jib	Hand	1
208	Jib	Hand	1
209	Jib	Hand	1
210	Jib	Hand	1
211	Jib	Hand	1
212-213	Jib	Hand	2
214	Jib	Hand	1
215	Jib	Hand	1
216	Jib	Hand	1
217-218	Jib	Hand	2
219	15-ton Bridge	Electrical	1
220	15-ton Bridge	Electrical	1
221	15-ton Bridge	Electrical	1

Blacksmith Shop

In order to make the largest engine and hull forgings, equipment consisting of a 1,000-ton, high-speed steam hydraulic forging press, a smaller press, and steam hammers is required, as well as furnaces and heat treating equipment necessary in connection with the operation of presses of this size. A building of 400 feet by 100 feet is provided for all forgings. An effort will be made in laying out this shop so that it will have a straight line flow of work.

All the steam pipe lines and air pipe lines will be run underground so a smooth floor can be obtained.

Coal furnaces will be used because coal is cheaper and easier to obtain in China; and electrical furnaces will be used for heat treating purposes due to their ease of temperature control.

This shop will be divided into three bays, one for large forges, one for small forges, and the other for hand forges. The use of forges is becoming less nowadays due to the increasing use of welding. Although the capacities of the individual machines are to remain the same, the total capacity of the shop in this yard will be only 70 per cent of the capacity of American blacksmith shops as they exist at the present time.



Blacksmith Shop Equipment List

Key No	Name	Size
01 to 02	Locker	20' x 3'
03	Tool Rack	
04 to 05	Col Furnace	21' x 16' x 9'
06 to 07	Coal Bunker	15' x 9' x 5'
08 to 09	Tool Rack	
10	Coal Bunker	10' x 8' x 5'
11	Coal Furnace	20' x 10' x 7'
12 to 18	Coal Bunker	7' x 5' x 5'
19 to 25	Coal Furnace	7' x 10' x 7'
26	Tool Rack	
27	Trimming Press	40" Stork
28	Emery Gringer	24" x 4½"
29	Steam Harmmer	4 Ton.
30	Shear Machine	5" Dia.
31	Steam Harmmer	5 Ton.
32	Trimming Press	30" Stork
33	Steam Harmmer	3 Ton.
34	Hot Saw & Burning Machine	
35	Hydraulic Press	600 Ton.
36	Shear Machine	8"
37	Steam Harmmer	12 ton.
38	Trimming Machine	60" Strok
39	Steam Harmmer	7 Ton.
40	Emery Grinder	24" x 4½"

Blacksmith Shop Equipment List

Key No	Name	Size
41	Trimming Press	40" Stork
42	Steam Harhammer	1 Ton.
43 to 44	Steam Harhammer	2 Ton.
45	Water Tank	15' x 5' x 4'
46	Oil Tank	8' Dia x 4'
47	Steam Harhammer	$\frac{1}{2}$ ton.
48 to 49	Anvil	3' x 5'-6"
50	Molten Cyanides Tank	
51	Electrical Furnace	15' x 7' x 4'
52 to 57	Coal Bunker	8' x 4' x 5'
58 to 65	Coal Forge	3'-6" Dia.
66 to 69	Coal Forge	5' Dia.
70 to 71	Anvil	3' x 5'-6"
72 to 79	Anvil	3' x 3'

Blacksmith Shop Crane List

No	Type	Size
15	Jib	5 ton. 18' Rad.
2	Bridge	30 Ton.

Galvanizing Shop

The building consists of an iron framework with corrugated plate walls, and covers an area of 11,352 square feet. One overhead five-ton bridge-crane is furnished for handling plates and shapes. Hot galvanizing is adopted in the yard. One sand blast machine is used for cleaning castings, and one hydro-fluoric acid tank is used for the same. There is one 25 feet long, 10 feet wide and 3 feet deep paint removal solution tank of welded steel. There are two hot water tanks, both having dimensions of 25 feet long, 10 feet wide and 5 feet deep. One is used as a quench tank, and the other is used as an acid rinsing tank. Both of these two tanks are made of concrete. Two acid tanks ( $H_2SO_4$  - 5%), one for shapes and one for plates, are placed between the hot water tanks. The tank for shapes is 25 feet long, 10 feet wide, and 3 feet deep. The tank for plates has the dimensions of 25 by 10 feet and 5 feet deep. These two acid tanks are made of welded steel plates with rubber liner and are lined with acid proof bricks. One tank of molten zinc is placed near the high temperature oil burning furnace. The capacity of the tank is 150 tons with the dimensions of 27 feet in length and 12 feet wide and a depth of 6 feet. This tank is kept at a definite temperature by passing hot gases through the coils around the tank. The hot gases are supplied by the furnace. A small wooden acid tank of 8 feet by 30 inches by

20 inches is provided for pickling small articles. One centrifugal galvanizing machine is used to galvanize these small articles. The plates and shapes are brought to and from the shop by means of standard gauge railroad trucks.

Woodwork Shop

This shop actually consists of four shops and a tool room. These four shops are: joiner, carpenter, pattern, and wood mill. The usefulness of these shops has been discussed in the last section, so we need not discuss it again. But the reason for putting these shops in one building is mainly to save machinery. That is, since these shops are all working on wood, the equipment they use is almost the same; so, by putting them into one building, the number of machines can be greatly reduced without reducing the output of these shops.

A separate tool room to prepare all the tools used in this shop can increase the efficiency a great amount. This is believed to be so because the time for the individual worker to prepare his tools is considerably longer than the expert tool preparation worker requires to do the same job.

Pattern shop: The number of patterns has been decreased due to the increased use of welding, so the pattern shop will be smaller than it would have been ten or twenty years ago.

Carpenter shop and joiner shop are merely the base required for workers in these shops because the main work of both of them is in the building slip or fitting out piers.

Wood mill: In this yard it is rather a re-saw station than a mill. The maximum size that can be handled in this mill will be 50 inches by 50 inches in cross section.

Special attention to fire fighting will be made in this shop due to the inflammability of wood.

Woodwork Shop Equipment List

Key No	Name	Size
1	Band Saw	54"
2	Work Table	
3	Rip Saw	36"
4	Rip Saw	18"
5	Work Table	10' x 5'
6	Planer	42"
7	Planer	36"
8	Moulders	16"
9	Jointer	6"
10	Jointer	18"
11	Lathe	40" x 22'
12 to 13	Lathes	24' x 8'
14	Gule Press	20' x 8'
15 to 16	Scroll Saws	4'
17	Chisel Mortising Machine	4'
18	Hand Clamping Machine	5' x 3'
19	Work Bench	2' x 11'
20 to 28	Work Benches	8' x 2'
29	Tenoning Machine	12"
30 to 31	Disc Sanders	36"
32 to 35	Drill Press	12"
36 to 37	Jointer	6"
38	Band Saw	36"
39 to 40	Scroll Saw	36"
41	Rip Saw & Cross Cut	24"

Woodwork Shop Equipment List

Key No	Name	Size
42	Rip Saw	18"
43	Forming Machine	8"
44	Mortising Machine	48"
45	Univ. Milling Machine	65"
46	Speed Lathe	12" x 3' c-c
47	Lathe	3'
48	Embossing Press	5 H.P.
49	Planer	36"
50	Embossing Press	5 H.P.
51 to 52	Jig Saw	48" x 20"
53 to 54	Disc Sander	36"
55 to 57	Work Bench	8' x 2'
58 to 59	Work Table	8' x 4'
60	Cutter & Grinder	
61	Saw Filer	
62	Saw Grinder	
63	Grindstone	24" x 2½"
64	Band Saw Stretching Machine	
65	Band Saw Setting & Filing Machine	
66	Band Saw Grinder	
67 to 68	Emery Grinder	28" x 4"
69 to 70	Work Table	5' x 3'
71 to 72	Chisel Grinder	
73	Locker	3' x 3'
74	Tool Racks	

Woodwork Shop Equipment List

Key No	Name	Size
75	Tools Issue Desk	6' x 2'
76 to 77	Band Saw	76"
78 to 79	Jointer	45"
80	Planer	120"
81	Planer	36"
82 to 83	Boring Machine	8'
84	Jig Saw	4'
85	Tenoning Machine	12"
86	Mortising Machine	4'
87	Rack For Mouldings	
88	Universal Saw	96"
89 to 91	Portable Hand Power Drill	
92 to 94	Portable Hand Power Shear	
95 to 100	Work Bench	8' x 2'
101	Work Table	10' x 4'
102 to 103	Jig Saw	48"
104 to 107	Band Saw	96"
108 to 109	Universal Saw	50"
110 to 112	Rip Saw	48"
113	Panel Raiser	4' x 4'
114	Jig Saw	48"
115	Work Table	10' x 4'



Turret Shop

One of the serious problems connected with the building of naval vessels is the completion and installation of the turrets during the period of construction of the vessel. With comparatively limited weight handling facilities, the construction of the turret cannot proceed beyond the assembly of the bare structural work until after the vessel is launched, the heavy structure being handled in separate pieces to be assembled on board the vessel. The large amount of fitting and installing then remaining occupies the entire time until the vessel is completed. A method of construction which offers much brighter prospects for rapidity is to build the turrets complete in a shop, then remove the armor and guns and strip the turrets to a weight that can be handled by the fitting out cranes, and to lift the turrets on board in this condition soon after launching. With cranes of the capacities described above, this process is entirely feasible, but involves the provision of a turret shop. In order to get the maximum benefit of the fitting out cranes, the capacities of the shop cranes should be equal to the fitting out cranes.

Foundry

Provision will be made in this new foundry for the production of all sizes and character of castings used aboard vessels. The building is to have two main bays, one for ferrous metals, and the other for the nonferrous metals. The equipment includes both electrical and open hearth furnaces, able to make the largest castings called for by the vessels.

The Other Shops

The other shops, such as sheet metal shop, copper shop, paint shop, and power house, will not be discussed in detail, but the sketches and equipment lists will be included.

Sheet Metal Shop Equipment List

Key No	Name	Size
01 to 06	Hand Rolls	4'
07	Slip Rollers	4'
08 to 09	Hand Brake	8'
10	Cornish Brake	8'
11	Hand Bar Folder	30"
12	Metal Band Saw	26"
13	Spot Welder	75 KVA
14	Band Saw & Circular & Planer	27"
15	Universal Iron Bender	2 Ton.
16	Compression Riveter	$\frac{1}{4}$ " Rivets
17	Sheet Metal Brake	12 Gauge 8' Long
18	Arbor Press	17" x 10"
19	Small Shear	16 Gauge 3'
20 to 22	Gate Shear	10 Gauge 8'
23	Erecting Platen	20' x 20'

Copper Shop Equipment List

Key No	Name	Size
1	Horizontal Hydraulic Bender	70 Ton.
2	Metal Band Saw	14"
3	Metal Band Saw	16"
4	Pedestal Grinder	8"
5 to 8	Electrical Furnace	4' x 5'

Paint & Rigging Shop Equipment List

Key No	Name	Size
01 to 03	Paint Shaper	5 gal.
04	Paint Grinder	5 gal.
05	Paint Conditioner	10 gal.
06	Paint Sprary Booth	14' x 16'
07	Rejnvenator	50 gal.
08	Portable Cleaner	5 hp.
09	Barrel Elevator	1,000 lb.
10	Hydraulic Wire Cutter	75 Ton.
11	Grinder	6"
12	Electrical Drill	3/8 "
13	Sewing Machine	

No Layout of shop shown for Copper, Paint and Rigging Shop.

Foundry Shop Equipment List

Key No	Name	Size
01 to 04	Electric Furnace	10 Ton.
05 to 08	Open Hearth Furnace	15 Ton.
09 to 10	Sand Mold Baking Oven	18'x28'x 10'

Turret Shop Equipment List

01 to 02	Gun Foundation Turning Machine	109"
03 to 04	Gun Foundation Turning Machine	40 MM Gun.
05 to 07	Torpedo & gun Director Foundation Turner	

Turret Shop Crane List

No.	Type	Capacity
3	Bridge	50 Ton.

Power House Equipment List

Key No	Name	Size
01 to 06	Straight Tube Sectional Header Travelling-grate Stoker Boiler	4,000 K.W.
07 to 10	High Pressure Steam Turbine	4,000 K.W.
11 to 14	Generator	4,000 K.W.
15 to 17	Air Compressor	4,550 Cu.ft./min.
18 to 21	Feed Water Pump	18" x 10" x 36"
22 to 23	Service Pump	18" x 10" x 36"
24	Accumulator	
25	Pulvirizer	
26 to 27	Fire Pump	8" x 10" x 12"
28 to 29	Sanatory Pump	6" x 10" x 12"
30	Drinking Water Pump	10" x 7" x 12"
31	Water Tower	
32	Coal Shaver	
33	Smoke Stack	
34	Control Panel	

## WORKERS' TRAINING

China is a farming country. But for the sake of promoting the peoples' living standard and making herself strong enough to take an active part in keeping the world peace, she has to develop as quickly as possible and become industrialized. For the development of her industries she wants thousands of miles of railroad and a great number of tonnage for shipping. We can imagine there will be a great future for China's shipbuilding industry. How can she get so many ship workers for her immediate need? In answering this question it is better to take a look at somebody else's experience first and then make a suggestion. The United States was so successful in various trainings during the Second World War. It would be beneficial for us to survey their ship workers' training in that period. Then we shall propose a workers' training program for this shipyard. If it is good for this yard, it will also be good for another yard provided we make some necessary changes.

A. The United States Ship Workers' Training during the Second World War

Apprenticeship in U.S. Navy Yards

The following excerpts from Captain C. W. Fisher's paper, "What the Navy Department Is Doing to

Train the Civilian Employees," presented before the American Society of Mechanical Engineers in December 1940, give a brief description of the apprenticeship training system of Navy Yards:

"For over fifty years the Navy Department has had a regular four-year apprenticeship system for training mechanics in the various trades....

"The Navy Department's civilian apprenticeship training is similar to the accepted apprentice systems. The principle underlying our apprenticeship system is to train mechanically-minded young men to become skilled artisans, to provide education in continuation of their schooling, to develop their characters and pride in their vocations, to inculcate in them patriotism and loyalty, and to make them useful citizens in their communities. This broad training has made it possible for many apprentices to advance to supervisory positions after satisfactory experience as artisans. Apprentice schools are now conducted at fourteen navy yards and stations, and offer training in thirty different trades. They are operated under joint regulations of the Navy Department and the United States Civil Service Commission. Last year approximately 2100 were in training and it is expected that about 4000 will be in training at the end of 1940.

"Classroom instruction, as distinguished from practical work in the shops, averages six hours a week, and is given by qualified employees selected for this duty or by experienced vocational teachers assigned by the state or local Board of Education.

"The normal length of apprenticeship is four years, upon satisfactory completion of which a certificate is awarded and the apprentice promoted to artisan in his trade at the minimum rate of pay. His further advancement is dependent upon his ability and the existence of vacancies in higher grades. In order to assist in overcoming the shortage of experienced mechanics in some trades, a procedure was recently established for the advancement of the most capable apprentices in these trades to journeyman ratings after the completion of three years of apprenticeship."



### Apprenticeship in Shipyards

The methods used in handling apprentices may be illustrated by some typical examples:

YARD A. This yard, which is located in a small community, employs about 3200 men. On September 8, 1939, it employed about 2570 men, of whom about 2370 were engaged on production work. The corresponding figures as of January 1, 1941, were:

Approximate number of employees	3200
Approximate number of employees on production work	2970

For some years an apprenticeship system has been in effect in the machine shop of this yard. In general the apprentices are high school graduates. They work as apprentices in the machine shop for four years, during which time they receive no instruction from school books or from formal lectures. They are shifted from one department of the shop to another with a view to developing them into competent mechanics by the end of the training period. They work during the regular hours in effect in the yard. At the end of four years the apprentices are rated as mechanics. At present a formal agreement applicable to apprentices is under consideration by the yard. The number of apprentices on September 8, 1939, was about 45, and the number on January 1, 1941, was about 69.

The apprenticeship system described above is about as simple as possible. Nevertheless, as used in this particular yard, it appears to have produced satisfactory results.

Apart from the above system, the yard has a cooperative arrangement with the local vocational high school. Boys from the school come to the yard as observers and in this capacity they spend four three-week periods in the yard during each of their last two years as high school students. During their periods in the shipyard they are required to keep the regular yard working hours. The boys are distributed among the various shops in the yard where they come under the observation of the supervisory force of the yard. The boys are given an opportunity to see the work being done and to engage in it, if they so request. Normally about a dozen students engage in this plan at any one time. In many cases the high school boys are given summer employment in the yard as helpers.

The above cooperative plan offers many of the advantages of a formal apprenticeship system. It maintains an interest in the shipyard among local high school boys and it furnishes the yard with a regular supply of young men capable of being developed into excellent mechanics after their graduation from high school.

The effectiveness of the very simple apprenticeship system in effect at this yard and of the cooperative plan outlined above is made possible by the high morale of the yard and the close ties which it maintains with the local community, and the hinterland beyond.

YARD B. The following statistics apply to a shipyard of moderate size engaged in building a highly specialized product:

	<u>Sept. 8, 1939</u>	<u>Jan. 1, 1941</u>
Approximate number of employees	3160	3700
Approximate number on production work	2825	3360
Approximate number of apprentices	267	338

The apprentice training program in this yard applied to thirteen mechanical trades including welding and also to drafting. In September, 1939, there were fifteen apprentice draftsmen in the yard, and in December, 1940, there were eighteen.

The apprentice training system is described in detail in a set of rules and regulations which sets forth important features of the program, such as qualifications of applicants; length of apprenticeship; rates of pay, scope of training and that of correlative school instruction; marks; examinations and promotions; certificate of graduation; supervision of the training

system; and rules of conduct.

Each incoming apprentice is required to sign an agreement which prescribes the contractual relationships between the apprentice and the company.

Applicants for apprenticeship are subjected to a physical examination conducted by a designated physician. Applications are accepted only from those having a high school education or equivalent as determined by examination. Age limits of applicants without trade experience may be employed as apprentices with advanced standing and at correspondingly advanced age.

The term of apprenticeship comprises four, eight or ten periods, each of which consists of 1000 hours of employment including 49 hours of school work for welder and 98 hours for other trades.

The term of apprentice welders is four periods, while that of most of the other trades is eight periods. Apprentice loftsmen, pattern makers, tool makers and draftsmen serve a term of ten periods.

For all apprentices there is a probationary period of from 1000 to 1160 hours of employment. During this period the agreement may be terminated by either party.

The work week of apprentices is the same as for other employees. Apprentices may be required to

work overtime, but this overtime does not affect the term of apprenticeship.

The correlative school work is conducted in recitation and lecture rooms within the yard. At present there are about eighteen men in each class, but the yard hopes to reduce this number to not over twelve. The school work is conducted for forty-nine weeks of each calendar year and operates on a five-day week basis. Apprentice welders attend for two hours per week, while apprentices of other trades attend for four hours per week.

Four instructors handle the school work, two being company employees and two being supplied by the State Board of Education. The instructors in the company's employ were selected with care on the basis of adaptability as teachers and knowledge of their respective trades. For texts the school uses mimeographed notes furnished by the State Vocational Schools.

Instruction in practical knowledge of trade is handled by the yard foremen and other supervisors. In general charge of the entire apprentice program, however, is an official called the "Apprentice Supervisor." He is the administrator of discipline and the custodian of records as well as the coordinator and principal executive of the apprentice system.

Apprentices are marked monthly in trade progress and school work, the marks being on a percentage basis. The lowest satisfactory mark is 70.

Before advancement to the next higher classification each apprentice must pass a comprehensive examination on the work of apprentice period just completed. Failure on this examination is penalized by the addition of 160 hours to the period. Failure on re-examination is considered sufficient reason for termination of apprenticeship.

A formal graduation of apprentices is held twice a year, at which a certificate is awarded to each apprentice who has completed his full course within the previous six months.

YARD C. Yard C is a large establishment enjoying an excellent labor supply. The following data to this plant:

	<u>Sept. 8, 1939</u>	<u>Jan. 1, 1941</u>
Approximate number of employees	5650	10,200
Approximate number of production workers	4400	8,100
Approximate number of "improvers"	350	525

Up to July 1937 the yard had in effect an apprentice system. As of that date there were about 250 apprentices on the payroll, most of whom were assigned to the mold loft, pattern shop, machine shop or electrical shop.

In July 1937 the yard decided to supplant the apprentice system with a modified system in which the students were called "improvers." All of the apprentices were rerated to improvers at the same rate of pay they had before the change.

The aim of improver system is the same as that of an apprentice system; namely, to develop competent and loyal journeyman mechanics in various trades. The maximum term of training for improvers is 48 months and the minimum term is 40 months. Curtailment of the term is dependent upon individual aptitude and rate of learning and not upon the trade of the improver.

The age limits for applicants formerly were 18 to 23 years, but since the draft became effective these limits have been changed to from 18 to 20 years. Thus, all improvers taken on since this change was made will have had at least a year's experience in the yard when they become liable to being drafted. Exemption from the draft may be granted to improvers with at least a year's service in the yard.

At present only high school graduates are enrolled as improvers, preference being given to the sons of employees. There is a waiting list of applicants numbering from 100 to 150.

A school is maintained at the plant for the purpose of instructing improvers and other yard employees. Improvers are not required to attend the school, but they are encouraged to do so or to attend some vocational school outside of the yard. In December 1940 about 200 improvers were enrolled in the yard school, while about 40 were attending outside schools. Improvers are not paid while going to school, but the instructors in the school are paid by the yard.

There is some exception to the general rule that improvers are not paid while attending school. The exception applies to improvers in the assembly shop; these boys receive about half an hour of instruction at the beginning of each shift.

The instruction in the school deals mostly with mechanical drawing and shop mechanics; but it deals also with special features of various trades, the improvers being grouped in the school by trades.

The entire improver system operates under the direction of an ex-assistant foreman of the pattern shop. He gives all his time to this work and he has three full-time assistants who, however, spend some of their time



in instructing the improvers in the school. There are several other instructors who give their full time to the school.

The above supervisory force keeps in active touch with the records of improvers in the school and also in shops. The activities of the improvers are prescribed for each shop and the improver supervisors exercise supervision of the training in the shops. The following outline indicates briefly the schedule of field employment of improvers assigned to the sheet metal shop:

First, improvers are assigned to work with helper for a period of about four months. Next, improvers are assigned to work with mechanics for from one to eight months. Next, the improvers are put on production work under the supervision of a special instructor until they indicate that they are qualified to work by themselves. Then they are given independent jobs and are assigned helpers as necessary.

The schedules in other shops are not exactly the same as that for the sheet metal shop, but they are definitely prescribed so as to meet the needs of the respective shops.

As is the case with apprentices, improvers are paid on an hourly basis and the rate is increased at specified intervals.

Up to December 5, 1940, 162 boys had completed the course of improver training and had been rated as mechanics. Of this number 155 were still employed by the yard, eleven were leading men, and one was a sub-foreman.

In many respects the improver system is similar to an apprentice system, but the former is more flexible and it seems to have met needs of Yard C extremely well. It is in effect at this yard for twelve trades.

**YARD D.** This yard has been engaged for many years in the construction of commercial and naval ships of many types. It is located near a city of moderate size.

The following data apply to this concern:

	<u>Sept. 8, 1939</u>	<u>Jan. 1, 1941</u>
Approximate number of employees	8520	13,080
Approximate number on production work	7385	10,975
Approximate number of apprentices	350	475

The apprentice training program in this yard applies to 24 mechanical trades and also to drafting. In September, 1939, there were 68 apprentice draftsmen, and in November, 1940, there were 71.

The apprentice training system is described in detail in a booklet issued by the company. The booklet contains information on entrance requirements, length of course, rates of pay, names of trades involved, trade and school instruction, reports on performance, certificate of graduation, etc.

The agreement between the company and the income apprentice has not the character of an indenture. It does, however, imply definite responsibilities of both parties.

Each applicant is required before acceptance to pass a physical examination by the company's surgeon. Subsequent physical examinations may be required at any time during apprenticeship.

Applicants are rated from A to E on the basis of the relation of age, height and weight to the normal distribution of these factors as developed by life insurance companies. Group E applicants are not accepted.

Likewise the applicants are grouped according to scholarship, 4% being listed as A, 24% as B, 44% as C, 24% as D and 4% as E.

Each applicant receives a rating consisting of a fraction, the numerator of which indicates scholarship and the denominator of which applies to physique. Thus the rating A/C means that the applicant is A in scholarship

and C physically. Applicants are enrolled in groups according to the numerator and within a group according to the denominator.

Applications are accepted from boys between 17 and 21 years of age, but enrollment is deferred until the age of 18 has been reached.

Scholastic requirements for admission to apprenticeship are that the applicant shall have a high school education or the equivalent with full credit in algebra and plane geometry and that he shall have maintained a scholastic average of C or better. The applicant must not have attended an institution of higher education.

Some years ago the yard participated in an extensive study of the desirability of selecting apprentices on the basis of scores on certain aptitude tests. The results of the study were not such as to indicate the superiority of this method of selection. Nevertheless, the report of the investigation, "Apprentice Training for Shipyard Trades," Federal Board for Vocational Education, January 1932, is an extremely interesting document which contains a great deal of information about the apprenticeship system of Yard D.

The apprenticeship course in this yard covers not less than eight terms of six months each, the first

term being a probationary period. The yard's experience indicates that an apprentice who is a failure at one trade may be expected to fail at any other.

Shop courses for apprentices are based on thorough job analyses of the various trades. By these means each trade has been broken down into a number of sections called "blocks." For instance, one block of the pattern-making trade has to do with paper cutting edges. For each trade the blocks are arranged consecutively in the order of difficulty in learning. The description of each block includes lists of necessary tools and equipment and types of jobs within the block. The trade analyses, leading to the setting up of blocks of study, have been copyrighted.

The trade instruction of apprentices follows the sequence of the blocks of study, but throughout the course the apprentices perform bona fide production work. In each shop the apprentices are segregated and work under the direction of a shop instructor. There are from ten to eighteen apprentices per instructor. The shop instructors are highly skilled young craftsmen, especially trained in the art of teaching. About 90 per cent of them are ex-apprentices. They are rated as quartermen and assistant foremen.

The correlative academic instruction is conducted in a company school. The instructors are college graduates who have specialized in their respective courses. Classes are held in mathematics, chemistry, physics, mechanical drawing, shipbuilding, English, economics, plant management, etc. Apprentices receive thirteen hours of classroom instruction every two weeks. Except in the case of apprentice draftsmen, however, the school work is not given during the last year of apprenticeship.

Marks are assigned in scholarship and records of these are kept. The shop instructors assign marks ten times monthly on the basis of aptitude attitude of the apprentices. A special card is used for this purpose and this card is based on the Richards formula, which is explained in "Apprentice Training for Shipyard Trades."

A learning curve is maintained for each apprentice. Monthly he is given a composite mark in scholarship and in aptitude-attitude. Plateaus in learning curves are tolerated, but a definite trend downward is cause for dismissal.

Discussions are held among instructors and these serve to improve the quality of instruction through bringing to light defects and their correction, methods

of handling individual boys and other important aspects of the art of teaching.

There are a number of important extra-curricular activities conducted as adjuncts to the apprentice training system. Among these are athletic teams, a band, a school paper, a social hall and a bachelor dormitory. Upon completion of apprenticeship, each boy receives a bonus of \$100, an engraved certificate and a photographic reproduction of this testimonial reduced to pocketbook size.

YARD E. (intensive training).

This yard is of large size and is located near a metropolitan center with a fairly good labor supply. The following data apply to this concern:

	<u>Sept. 8, 1939</u>	<u>Jan. 1, 1941</u>
Approximate number of employees	7300	10,000
Approximate number of production workers	5900	8,050
Approximate number of apprentices	251	312
Approximate number of apprentice-draftsmen	22	27
Approximate number of apprentices in mechanical trades	229	285

In the summer of 1940 the yard decided to undertake a program of intensive training of unskilled men in a number of mechanical trades. The trades for which men have been trained or are in training under this program follow:

Shipfitting	Electrical layout
Chipping and calking	Sheet metal locker builder
Tank testing	Planer operator
Crane operator	Door mechanic
Elector	Bulkhead fitter
Mold loftsmen	Stiffener fitter

It will be observed that several of the above are not recognized trades throughout the industry, but are portions of trades.

The planning and operation of the entire program was placed in the hands of an experienced personnel executive. His first task was to decide on the method of instruction. The decision was to use both class and job instruction and to place about ten trainees under each instructor, who would have entire charge of the group both in school and on the job. Each craft was broken down through job analyses, and courses of instruction for the several crafts were developed by the prospective instructors and the head of the training department. The preliminary analyses and



planning of courses helped to train those chosen to instruct. Further training consisted of holding all-day conferences for a week. "The Instructor, the Job and the Man" by Allen was used as a reference and as a source of material for discussion at the conferences.

The instructors were selected with great care on recommendations of the yard departments to be served by the training program. Upon assignment instructors were given an increase in pay in recognition of their assumption of added responsibilities.

In the operation of the intensive training system in Yard E adjustments in procedures have been necessary from time to time and separate consideration has been given to each craft. In general, however, the current practice calls for an hour's lecture daily to each group of trainees, the rest of the time being spent on production work under the supervision of the instructor. In the lectures textbooks are not used; the lectures are based on outlines and notes worked up in conjunction with the job analyses. An outline of the course of lectures in shipfitting is given below:

1. Each student to provide himself with notebook and pencil to make notes and sketches.

2. Instruction to be given as to yard and work procedure, the location of the dispensary, offices of the department and names of the supervisors.
3. Instruction to be given in the need for safety.
4. Student to be told where and how to obtain necessary tools such as:

Hammers

Wrenches

Drift pins

Keel wedges

To provide himself with:

Rule

Square

Chalk line

Level

5. Explanation of course and what is hoped to be accomplished.
6. Explanation of shipfitting and what a shipfitter does.
7. Explanation and sketches to be given on the various materials that go into the construction of a ship, namely:

Angles

I-beams

Riveting

Bulb angles

Flat bars

Welding

Channel bars	Plates
Tee bars	Buttstraps
Zee bars	

8. The different parts of the ship to be defined and studied such as:

Flat and vertical keel		
Bulkheads	Longitudinals	Decks
Shell	Transverses	Stiffeners
Frames	Floor plates	Stringers
Beams	Tank tops	Brackets
	Web frames	Inner bottom
	Stanchions	Girders

9. The subject of lines:

Centerline	Sheer
Base line	Camber
Water line	Declivity
Buttock line	

10. Instruction in riveting to be given as to types of rivets, as

Snap rivets	Flush rivets	Butt joints
Countersink rivets		Lap joints

Also in the method of making off, spacing of oiltight and watertight members.

11. Instruction in welding to consist of explanation of welding symbols.

Vee butt (sketch and explanation)

12. Plan reading instruction to be given in:

Locating details and sections

Checking alternations

Number of plans

Plan reading, covering: Bulkheads, shells,  
foundations, decks  
deck houses.

13. Each student to receive a complete list of terms, abbreviations and symbols as compiled by instructors.
14. Periodic tests to be given to determine students' progress.

On December 1, 1940, 308 trainees had completed intensive courses and had been released to the various departments of the yard. Yard E is to be congratulated upon its bold initiative in undertaking this training system which already has yielded significant results.

B. A Proposed Training Program for this Yard

General

In setting up a training program we have to consider the following items.

1. Objectives
2. Time available
3. Subjects included
4. Equipment -- tools, supplies, movies, plans, models, etc.
5. Trainees -- How many will be trained.  
How to select them.  
How to group them into different classes.
6. Principles -- Use "Job Analysis" form simple to complicated.  
  
Well balance and relate class instruction and practical work.
7. Instructors -- How many wanted.  
How to select them.  
How much work for them.
8. Run by the yard or cooperate with vocational school.
9. Supervision of the training program.

Proposal

For this yard the authors have proposed training for several trades, such as shipfitters, loftmen, outside machinists, welders and supervisors. This yard will not use much welding at the very beginning, but the proposed training program for welders will be beneficial for the yard in the future. Workers needed in other trades may

be trained as apprentice learners in various shops because their number is not too large when various shops can easily get certain skill and semi-skilled workers from outside.

### Shipfitters' Training

#### Part I. Training for Beginning Shipfitters

The classes in training for beginning shipfitters are conducted by the shipyard. Each class consists of about 15 trainees.

##### Objective of Training for Beginning Shipfitters

1. To shorten the usual breaking-in period.
2. To develop basic skill in the use of tools and in handling materials.
3. To develop a knowledge of locations, terms, shapes, procedures, etc., pertaining to shipbuilding practice.
4. To lay a groundwork which will help the trainee to advance more rapidly in skill and knowledge as a result of his practical work experiences in the shipyard.

Suggested Minimum List of Tools, Equipment,  
and Supplies for a Beginning Course in Shipfitting  
(class of 15 trainees)

Tools

- |                            |                        |
|----------------------------|------------------------|
| 1. 5 ball peen hammers     | 10. 2 mauls            |
| 2. 5 center punches        | 11. Bending lever      |
| 3. Tit punch               | 12. Scratch awl        |
| 4. Spring punch            | 13. 2' steel square    |
| 5. Straight edge           | 14. Combination square |
| 6. 6-2' folding rules      | 15. Level              |
| 7. 6-6' folding rules      | 16. Declivity board    |
| 8. 6-50' steel tapes       | 17. Plumb bob          |
| 9. 6-6' spring steel tapes | 18. Back marker        |

Equipment

(including demonstration objects)

1. Heavy cleat, or similar piece, weight approximately 50 pounds.
2. Piece of sheared plate with sharp edges.
3. Assorted steel wedges
4. Assorted dogs
5. Yokes, made from plate, channel or angle
6. Flat bars and spacers
7. Scrap piece of flanged plate
8. Section model of a ship hull
- \*9. Hydraulic jack and pump
- \*10. Pump hose
- \*11. Safety helmet
- \*12. Safety shoes
- \*13. Lead hose and additional sections

- \*14. Impact wrench (knock-knock machine)
  - \*15. Portable pneumatic grinder
  - \*16. Welding equipment
  - \*17. Small portable arc welder for use in light tacking. Helmet, gloves, and electrode will also be needed. (A trainee who can properly tack weld should be present when welding equipment is in use.)
  - 18. 3/4" x 4' x 6' scrap plate
  - \*19. Steamboat ratchet
  - 20. Goggles
  - 21. Pads with holes to accommodate ratchet or turnbuckle
  - 22. 5/16" x 4" bolts
  - 23. 3/4" x 6" x 5' board
  - 24. Small templates
  - 25. Several small wooden blocks
  - 26. Small wooden wedges
- \*Equipment used for demonstration. This equipment is needed for specific lessons only.

#### Supplies

- 1. 10 pieces of soapstone
- 2. Chalk line
- 3. 5 pieces of scrap plate 3/4" thick
- 4. 10 pieces of 1/8" or 3/16" scrap plate, approximately 1' x 3'
- 5. 4 pieces of 5/8" x 4' x 30" plate
- 6. Scrap pieces of angles (equal and unequal)
- 7. Scrap pieces of channel



8. Scrap pieces of bulb angle
9. Scrap pieces of T-bar
10. Scrap pieces of I-beam
11. Scrap pieces of H-section
12. Scrap pieces of half-round
13. Scrap pieces of flanged plate
14. Scrap pieces of corrugated section
15. Scrap pieces of flat bar
16. 10 steel plates,  $1/8"$  or  $3/8"$  x 1' x 3'
17. 4-- $7/8"$  x 4" bolts
18. 12-- $7/8"$  washers
19. Chalk -- blue and white
20. Approximately 50 square feet strawboard
21. 5 pieces angle bar,  $1/2"$  x 3" x 3'
22. Approximately 100 square feet red template paper
23. Copy of "Shipfitting Practice" for each trainee
24. Blueprint of general arrangement plan of a ship for every two trainees in the class
25. Several blueprints showing layout of the shipyard or blueprint of a typical shipyard layout

Suggested Outline of Minimum Essentials for  
Training Beginners in Shipfitting

Time required: Approximately 60 hours of instruction,  
including shop talks, demonstrations, and  
shop practice.

1. Location of shipways, etc., in the yard
  2. Knowledge of tools and their uses
  - \*3. How to use a Hammer and Center Punch
  4. Knowledge of shipbuilding shapes
  5. General arrangement of a ship
  - \*6. How to strike a chalk line
  - \*7. How to use a rule or steel tape
  - \*8. How to hook up and use pneumatic tools
  9. Knowledge of other crafts' work
  10. Essential shipbuilding terms
  11. Knowledge of the flow of materials
  - \*12. Handling materials
  13. Fundamental processes employed in shipfitting
  - \*14. How to apply dogs and wedges
  - \*15. How to apply yokes
  - \*16. How to make and apply strongbacks
  - \*17. How to use a steamboat ratchet
  - \*18. How to use a hydraulic jack and pump
  - \*19. How to lay out plates of shearing, planing, and bevel planing
  - \*20. How to lay out angles of punching and shearing
  21. Elementary knowledge of the lines of a ship
  22. Declivity of shipways
  23. Safe practices in the shipyard
- \*shop practice (manipulative).

## Part II. Training for Advanced Shipfitters

The objectives of advanced training in shipfitting are:

1. To up-grade shipfitter helpers, linemen, or third-class shipfitters so that they may be capable of performing the duties of second-class shipfitters.
2. To up-grade second-class shipfitters so that they may be capable of performing the duties of first-class shipfitters.

### Suggested List of Tools

The following list of tools are furnished by the trainee for school purposes.

1. 2' folding rule
2. 6' folding rule
3. Pocket knife
4.  $1\frac{1}{2}$  lb. ball peen hammer
5. Combination square
6. 30 lb. cutty hunk chalk line
7. Center punch

The following list of tools are needed by the trainee on the job.

1. Tools listed for school purposes
2. 2' square
3. 6" try-square

4. 50' steel tape
5. Level
6. 9" dividers
7. Trammel points
8. Steel straight edges

Suggested Outline of Instruction for Advanced Training  
in Shipfitting

1. Location of frame lines
2. How to lift, layout, and regulate liners
3. How to lift and layout angles
4. How to make collars
5. How to use a gage reduction formula
6. How to lift, layout, and install brackets
7. How to expand lines of a ship
8. How to use a declivity board and level
9. How to layout and assemble a simple foundation
10. How to fit brackets in way of corrugated bulkhead
11. How to plumb a transverse bulkhead
12. How to "horn in" a section of a ship
13. How to set and scribe foundations
14. How to set a foundation after launching
15. How to lift a shell frame template from shop
16. How to lift shell plates (bilge)
17. How to layout shell plates (bilge)
18. How to use roll sets

19. How to layout a furnaced plate (from mold loft template)
20. How to layout and install airports
21. How to assemble and install steel casting -- stern frame, anchor handling, stem castings
22. How to fit engine room grating
23. How to fit engine room floor plates
24. How to lift and install deck ladders
25. How to locate and layout manholes
26. How to locate, layout, lift, and install doors and fittings
27. How to locate and install fittings for rigging
28. How to locate and set king posts and masts
29. How to locate and install mooring equipment
30. How to locate and install ventilation equipment
31. How to locate and install scuppers and freeing ports
32. How to locate and install pipe protection
33. How to locate and set oil tight hatches
34. How to locate and set dry cargo hatches and braces
35. How to locate and install equipment for navigating lights
36. How to develop a cylinder
37. How to develop the frustum of a cone
38. How to layout a camber curve
39. How to develop a cylinder with a sloping top
40. How to construct an ellipse
41. How to develop a right-angle intersection of two cylinders

### Training of Loftsmen

Loftsmen may be trained by the shipyard itself or by a nearby vocational school in cooperation with the shipyard. Anyway it is preferred to have class instruction. Each class has 20-25 intelligent boys with at least a high school education, including plane and solid geometry. The length of the course will be about four months. If the training is carried out by a nearby vocational school the shipyard should furnish a competent draftsman and the necessary lines and structural plans of a typical merchant ship. Have the school set aside a suitable drafting room half of which should be fitted out as a small mold loft.

It is proposed that the course in the school should include the following:

1. Classroom work in descriptive geometry
2. Practice in making geometrical models of stiff paper and in developing sections through the models. Frustrums of cones, intersecting cylinders, etc., would be suitable solids with which to deal.
3. Lectures and problems on the geometry of a ship
4. Lectures and problems on the structure of a ship
5. Riveting and welding symbols and laying out joints to scale of about one inch to the foot
6. Laying down lines to reduced scale on loft floor

7. Lectures on the tools for forming, cutting, punching and shearing structural members and on the marking of molds to indicate the corresponding operations
8. Making molds of typical structural parts to reduce scale
9. A carefully planned tour of the shipfitter shop and mold loft about midway in the course to illustrate objectives, to demonstrate the machine tools and process, and to enhance interest

It is suggested that the graduates of the proposed course could be put to advantage directly on production work in the mold loft of a shipyard. Of course, they would require close supervision and their molds would have to be checked before release to the structural shop.

### Outside Machinist Training

#### Part I. Outside Machinist Training for Beginners

##### Objectives of Training for Beginning Shipyard

##### Outside Machinists:

1. To shorten the usual breaking-in period
2. To develop basic skills in the use of tools and in the handling of materials

3. To develop a knowledge of location, terms, shapes, procedures, etc., pertaining to outside machinist practice
4. To lay groundwork which will help the trainee to advance more rapidly in skill and knowledge as a result of his practical work experience in the shipyard

Suggested Minimum List of Tools, Equipment and Supplies  
(for 10-15 Trainees)

Tools

1. 5 ball-peen hammers (2 lb.)  
10 ball-peen hammers (1 1/4 lb.)
2. 10-6" steel scales
3. 2-50' steel tapes
4. 3-6' steel tapes
5. 5-4" to 6" inside calipers
6. 5-4" to 6" outside calipers
7. 5-6" hermaphrodites
8. 5-prick punches
9. 5-center punches
10. 2 one-inch outside micrometers
11. 2 two-inch outside micrometers
12. 1 one-inch test guage
13. 1 inside micrometer
14. 5-4" dividers



15. 5-6" dividers
16. 5-8" dividers
17. Assorted cold chisels
18. 5 sets open-end wrenches
19. Large assortment of twist drills (straight and taper shank)
20. Large assortment of reamers
21. Hand-reamer wrenches (assorted)
22. 5 combination squares
23. Dummy pedestals, chocks, and foundations
24. Short round bars with holes drilled for reaming to taper-pin sizes
25. Large assortment of taper pins
26. Short pieces of shafting to fit reamed holes
27. 12 no. 4 taper hand reamers, spiral flutes
28. 12-1/2" taper machine reamers, spiral flutes
29. 12 twist drills for no. 4 taper pin
30. C-clamps, assorted sizes
31. 12-23/32" twist drills
32. 10-1/2" twist drills
33. 10-15/16" twist drills
34. 5-1" spiral flute reamer
35. 5-1" straight-flute reamer
36. 5 sets American Standard taps 1/2"
37. 5 sets American Standard taps 5/8"
38. 5 sets American Standard dies 1/2"

39. 5 sets American Standard dies 5/8"
40. Quantity of twist drills to suit taps
41. 12-10" half-round bastard files
42. Tap wrenches
43. Die stocks
44. Several stud drivers to suit studs
45. 5-12" Stillson wrenches
46. Assorted size easy-outs
47. 5-12" hack-saw frames
48. 4 doz. 12" hacksaw blades, medium
49. 15 pairs, approved type of goggles
50. 5 screw pitch guages, N.C.
51. 12-10" flat bastard files
52. Screw drivers, several assorted sizes
53. One dozen scribes
54. 5 each 3/8" and 5/8" key drifts
55. 4 pairs 14" tin snips
56. 4-24" spirit levels
57. 5 plumb bob and line
58. 5 thickness guages, 1.5 to 15 thousandths
59. Several adjustable wrenches, assorted sizes
60. 4-12" or 14" monkey wrenches
61. 6 pairs side-cutting pliers, 8" size
62. Assorted sizes 12-point box wrenches
63. Assortment of calking tools

64. Assortment of fox wedges
65. 12 one hundred-foot chalk lines
66. 6 each, flat and bull-nose scrapers of a suitable size for practice
67. 6 each, 3-corner and straight scrapers of a suitable size for the job
68. Assortment of packing hooks
69. Several drift punches of assorted sizes
70. 3 oilstones, carborundum, fine and coarse combination
71. Hexagon socket wrenches (various sizes as needed)
72. 2 sets conventional socket wrenches with ratchet handle
73. Several hexagon box wrenches
74. 5 sets trammels with 24", 48", and 60" beams
75. Several Allen wrenches for 1/4", 3/8" and 1/2" Allen set screws
76. 1 four-foot, cast-iron straightedge

#### Equipment

1. Wall scale with slides
2. Benches and 5" vises (10 at least)
3. Several pieces of pipe to fit over wrench for extra leverage
4. Air or electric drilling machine
5. Taper sleeves for drilling-machine chuck
6. Cutting oil and several oil cans
7. Broken or damaged drills
8. Corner drilling machine
9. Drilling post

Supplies

1. Scratch paper
2. Machined parts to be measured with a scale
3. Assorted sizes of round and square metal stock
4. Stock with bored, reamed, and drilled holes to be measured with calipers
5. Sheet-metal stock for layout purposes
6. Layout solution
7. Chalk
8. Several pieces round stock (precision ground) for practice measuring with micrometers
9. Several pieces of different sizes of piano wire or drill rod, 8" to 12" long
10. Several pieces of steel plate, 1/8" to 3/4" thick, and 10" to 12" long
11. Several pieces of plate, precision ground to thickness or width
12. Blueprints or mimeographed sheets showing several holes to be laid out
13. Cast-iron blocks or strips 1/2" x 3" x 12" and 1" x 3" x 12"
14. Several bored journals, 4" diam.
15. Assortment of square and hexagon nuts
16. Flat bar drilled to accommodate various diameters of bolts (several pieces of various sizes)
17. Quantity of various sizes of studs
18. Several pieces of stock with drilled holes to be reamed later
19. 4 taper pins (4 dozen)
20. Iron or steel couplings bored 23/32" inside diameter

21. Steel plates drilled  $15/32$ " (quantity)
22. Steel plates drilled  $23/32$ " (quantity)
23. Brass couplings bored  $23/32$ " diameter (quantity)
24. Several  $3/4$ " C. R. rods
25.  $1/2$ " Steel plates with  $7/16$ " drilled holes along the plate edges. Plates to be tack-welded together in pairs with the rows of holes almost lines over each other for practice reaming
26. Quantity of  $1/2$ " bolts,  $1\ 1/2$ " long (with nuts)
27. Several wood blocks cut half-round to hold couplings and rods in a vise.
28. Bushings for  $3/4$ " hole bored  $3/8$ " I.D.
29. Four dozen  $3/4$ " fitted bolts,  $0.7505$ " O.D. (length optional)
30. Four dozen black bolts (length optional)
31.  $3/4$ " Steel plates  $18$ " x  $36$ " (one dozen)
32.  $1/2$ " bushings to fit  $15/16$ " holes
33. Four dozen  $1.00025$ " fitted bolts (optional length)
34. Four dozen  $1$ " black bolts (optional length)
35.  $3$ " x  $4$ " chocks (quantity)
36. Flat steel-plate scrap for practice tapping
37. Quantity of round stock to suit dies
38. Quantity of bolts to be rethreaded
39. Quantity of nuts to suit taps
40. White lead
41. Several steel or iron pieces with topped holes of the stud to be used
42. Iron or steel plates containing several broken-off studs

43. Wood blocks into which screw may be driven for practice
44. Several steel plates tapped for various sizes of machine screws
45. Large assortment of 12" square, 12" mill, and 12" flat bastard files
46. Large quantity of boiler plate, 1 1/2" wide x 3/8" thick
47. Several each of round and square brass bars, 1" x 1" x 12"
48. Quantity of cast-iron bars, 1" x 2" x 12", with one of the 2" edges machined
49. Quantity of plain and gib-head keys
50. Quantity of shafting and couplings for key-fitting practice
51. Quantity of Allen set screws 1/4", 3/8", and 1/2"

Suggested Outline of Minimum Essentials for Training  
Beginners in Outside Machinist Work

Time required: Approximately 365 to 503 hours of instruction, including shop talks, demonstrations, and shop practice (practical work by trainee). After the training the trainee will be qualified as outside machinists' helpers.

1. Safety practices in the shipyard
2. Location of various shops, tool cribs, and storerooms
3. Care and use of tools and equipment owned by the trainee
4. Care and use of tools and equipment owned by the yard
5. General arrangement of a ship

- \*6. How to read and use a mechanic's scale
- \*7. How to use calipers, dividers, and morphs
- \*8. How to read and use the micrometer
- \*9. Correct use of machinists' hammer and center punch
- \*10. Types and uses of cold chisels
- \*11. How to select and use open-end wrenches
- \*12. How to select and use twist drills and perform drilling operations
- \*13. How to select and use reamers and perform reaming operations
- \*14. How to proceed when reaming "through" holes
- \*15. Care and use of a portable air drill
- \*16. How to thread bolts and nuts and tap holes
- \*17. How to tighten a stud in a threaded hole
- \*18. How to remove studs or broken bolts
- \*19. How to use and care for a screwdriver
- \*20. How to select and use various types of files
- \*21. How to fit a key
- 22. The care and use of other outside machinist tools listed in Part I.
- \*Shop Practice (manipulative)

## Part II. Training for Advanced Shipyard Outside Machinists

Objectives of Advanced Training for Outside Machinists.

1. To up-grade outside machinists' helpers of the

laborer level so that they may be capable of performing the duties of second-class outside machinists.

2. To up-grade second-class outside machinists so that they may be capable of performing the duties of first-class outside machinists.

Note: It is highly desirable that each of the above objectives be considered separately. Classes should be organized for each group. It is further desirable that the groups be broken down into specific block-training procedures, that is, training for certain work should be given to a selected group. For example, training in chock fitting may be given to men who have shown a tendency to perform this job well. Training in aligning pump and motor units may be given to another selected group. These selections should be made after careful consideration as to what section of the shipyard the trainee will be assigned upon the completion of the course. Advancing from outside machinists' helper to second-class machinist requires considerable yard experience in addition to the instruction given in Part I and II.



Tools To Be Furnished by the Trainee for School Purposes

1. 6" Steel scale
2. 6' Steel tape
3. 1 3/4 lb. machinists' hammer
4. Pocketknife
5. Lead pencil
6. 6" spring dividers
7. 6" inside calipers
8. 6" outside calipers
9. 6' folding rule
10. Set of open-end wrenches
11. Center punch
12. Prick punch
13. 12" combination square
14. Thickness gauge
15. 1" outside micrometers
16. 6" side-cutting pliers
17. Plumb bob and line
18. 1" flat cold chisel
19. Scriber

Tools To Be Furnished by the School

1. Portable grinder
2. Necessary files
3. Stillson Wrench
4. Packing hooks

5. Valve-seat remover
6. Socket wrenches
7. Tap die sets
8. Small leveling jacks
9. Tap die sets
10. 50' steel tape
11. Trammel with beam
12. Adjustable wrenches 1/4" to 1"
13. 24" level
14. Assorted C-clamps
15. Drilling machine
16. Necessary reamers
17. Necessary drills
18. Dial indicator
19. Spoon scraper
20. Flat scraper
21. Hand scraper
22. 3-cornered scraper
23. Turn scraper
24. 3' pinch bar
25. 20-lb. maul
26. Taper-pin reamers
27. Stud drivers
28. Declivity board
29. Mock-up bearing and journal

Supplies

1. Assortment of cast-iron chocks in the rough
2. Steel plates of various thickness, widths, and lengths
3. Mock-up foundation
4. Chock sheets
5. Blue chalk
6. Marking paint
7. Gasket material
8. Thread dope
9. Pipefitting
10. Lamp wicking
11. Stuffing-box packing
12. Red-lead putty
13. Steam packing
14. Grinding compound
15. Mock-ups in valve seats, valve disc
16. Template wood
17. Soapstone pencils
18. Bolts and nuts as required
19. Flange couplings
20. Steel wedges
21. Side jacks
22. Set screws
23. Shims
24. Prussian blue

25. Lead wires
26. Shim stock
27. Cleaning fluid
28. Cup grease
29. Lead cards
30. Cleaning rags
31. Wire-inserted sheet rubber packing

Suggested Outline of Instruction for Advanced Training in  
Outside Machinist

Time required: Approximately 130 to 190 hours of instruction, including shop talks, demonstrations, and shop practice.

1. How to use and care for a portable grinder
2. How to fit various types of chocks
3. Where to use various gasket materials and thread dope
4. How to make a full face gasket
5. How to make a ring gasket for a standard six-inch flange joint
6. How to cut a dovetail gasket
7. How to pack a stuffing box
8. How to make a water-tight joint
9. How to overhaul valves
10. How to check and grind valve seats
11. How to set a valve
12. How to use a declivity board and level
13. How to strike a chalk line under various circumstances

14. How to select, set, and fit a deck stand
15. How to install a pump
16. How to align pumps, motors, and couplings
17. How to overhaul a steam pump
18. How to spot and scrape bearings
19. How to install operating rods correctly
20. How to fit a sea-chest strainer plate
21. How to install valves
22. How to install overboard spools

Part III. Training for Installation, Maintenance and Repairs

Objectives of Installation, Maintenance, and  
Repair Training for Outside Machinists:

1. To up-grade further the outside machinist who has successfully learned the majority of the knowledge and skills outlined in Parts I and II.
2. To train second-class outside machinists for specific installation jobs which involve the placing, aligning, and securing of heavy, intricate machinery and equipment aboard ship as well as the maintenance of these units.
3. To train second-class outside machinist to make permanent repairs in a skillful manner in the shortest time possible on the above-mentioned equipment and to assume responsibility for the

layout work involved in running a tight line,  
boring a stern tube, aligning a propulsion  
motor, etc.

Suggested Minimum List of Tools, Equipment, and Supplies  
for Installations, Maintenance, and Repairs Training Course  
in Shipyard Outside Machinist  
(Class of 10-15 Trainees)

Tools

1. Tools listed in Parts I and II
2. 12" level
3. 30-lb. sledge
4. 24" inside calipers
5. Special telescopic gauge
6. Taper gauge
7. 10-lb. maul
8. 20-lb. maul
9. Diesel side jacks
10. One 12" drill extension
11. Shipfitter's taper reamer
12. Spoon bearing scraper
13. Special trammels

Equipment

1. Tight line
2. Target stands
3. Special target-stand accessories
4. Sag blocks

5. Mock-up bulkhead
6. Small-sized portable boring bar
7. Mock-up assembly of stern-frame eye
8. Mock-up shaft alley
9. Hydraulic pump
10. Hydraulic ram
11. Strongback assemblies
12. Pull bolt, saddles, and washers
13. Stern-tube nut wrench
14. Mock-up boiler foundation
15. Melting ladle
16. Pouring ladle
17. Heating torch
18. Mock-up stern tube
19. Metal hand for tight metal
20. Mock-up stator and rotor
21. Bailey Feed Water Regulator
22. No. 4 corner drilling machine
23. Oilstone
24. Two round steel bars 18" long to fit holes in mock-up winch foundation
25. Anchor-winch mock-up
26. Wood foundation mock-up for anchor winch
27. Mock-up foundation channels
28. Wedges, blocking
29. Acetylene-welding equipment

30. Main steering-gear ram mock-up
31. Main steering-gear ram foundation mock-up
32. Chocks
33. Special spanner wrench
34. Mock-up propeller
35. Mock-up tail shaft
36. Mock-up stern frame and shaft alley
37. Mock-up fairwater
38. Mock-up scaffold
39. Model of a ship hull on the ways ready for launching

#### Supplies

1. Cleaning rags
2. Planking and bagging
3. White lead and oil
4. Tight metal
5. Clay for mud seal
6. White-pine stick for testing of tight metal
7. Insulated studs
8. Shim stock
9. Various valves, fittings, and accessories to be installed on boiler front
10. Red lead
11. Tarred felt
12. Tacks for tarred felt
13. Layout fluid
14. Chock sheets



Suggested Outline of Minimum Instruction for Outside  
Machinist Installation, Maintenance, and  
Repairs

Time required: Approximately 106 to 140 hours of instruction, including shop talk, demonstrations, and shop practice.

1. How to run a tight line
2. How to remove a tight line
3. How to set a portable boring bar
4. How to bore a stern frame
5. How to "pull in" a stern tube
6. How to install a propulsion motor
7. How to install a fan and motor for an air cooler
8. How to install accessories on a steam boiler
9. How to install winches
10. How to install a steering gear and telemoter
11. How to install a propellor and tail shaft
12. How to prepare a tanker for launching

Training of Welders

This program has two stages: the first is intended to produce tack welders, and the second, arc welders. In both cases the training problem resolves itself into repetitive practice until a sufficient degree of manipulative skill, essentially a dexterous wrist motion, is required.

It is not practical to give this type of training on the job because of spoilage, and it is therefore necessary to route the steel plate scrap from the plate shop to the welding school where student burners (a profitable parallel training course) will cut the scrap into exercise pads of suitable size for use by the welding students. After having served this double training purpose, this scrap will then find its way to the electric furnace for remelt.

To serve its full purpose, the building which houses welding training should be designed for that purpose only, since the elimination of heat and fumes as well as the shielding of arcs must be provided. Essentially, booths are placed in rows along the center-line of an A-roof building, each booth being open at the top and bottom to permit the free flow of air. Resistors are located high in the ceiling so that the heat may be more readily dissipated. A blower delivers fresh air into each booth near the bottom, and fans exhaust both heat and fumes through ventilators in the ridge of the roof. Each booth is provided with a switch-board so that the student may adjust current valves.

Within the individual booth there is a table (actually the top of the fresh air duct) and a welding stand, which is a vertical frame supporting a tilting

plate, shoulder high. This adjustable stand, hinged horizontally along the center, permits welding either vertically or overhead. Flat welding is done on the table top.

Wide aisles are located along the side walls of the building. At convenient points water troughs are placed so that the specimen may be cooled for examination. Close by is a metal top table on which the student may clean his specimen with hammer and wire brush. There is also a hydraulic jack to be used in fracturing the specimen for examination of the weld.

In the lobby, which also serves as an office, there are display boards of sample welds; here the learner may compare his work with standards. As far as possible everything is of fireproof construction.

There are two things to be taught the learner (1) how to deposit metal, and (2) how to use this newly acquired skill in joining metal. The list of exercises used in training both tack welders and arc welders is given below:

<u>Lesson No.</u>	<u>Arc</u>	<u>Tack</u>
1. Single beads in flat position	x	x
2. Double beads in flat position	x	x
3. Pad of crossing beads in flat position	x	x
4. Single beads in 45-degree flat position	x	x

<u>Lesson No.</u>	<u>Arc</u>	<u>Tack</u>
5. Double beads in 45-degree flat position	x	x
6. Pad of crossing beads in 45-degree flat position	x	
7. Single beads in vertical position	x	x
8. Double beads in vertical position	x	x
9. Pad of crossing beads in vertical position	x	
10. Single beads in 45-degree overhead position - welding upward	x	x
11. Double beads in 45-degree overhead position - welding upward	x	x
12. Pad of crossing beads in 45-degree overhead position	x	
13. Single beads in overhead position	x	x
14. Double beads in overhead position	x	x
15. Pad of crossing beads in overhead position	x	
16. 1/4-inch fillet weld in flat position	x	x
17. 3/16-inch fillet weld in flat position	x	
18. 3/8-inch fillet weld in flat position	x	
19. 1/4-inch fillet in vertical position	x	x
20. 5/16-inch fillet weld in vertical position	x	
21. 3/8-inch fillet weld in vertical position	x	
22. 1/4-inch fillet weld in overhead position	x	x
23. 5/16-inch fillet weld in overhead position	x	

<u>Lesson No.</u>	<u>Arc</u>	<u>Tack</u>
24. 3/8-inch fillet weld in overhead position	x	
25. Lap weld in flat position	x	
26. Lap weld in vertical position	x	
27. Lap weld in 45-degree overhead position - welding upward	x	
28. Lap weld in 45-degree overhead position - welding horizontally	x	
29. Lap weld in overhead position	x	
30. Butt weld in flat position	x	
31. Butt weld in vertical position	x	
32. Butt weld in overhead position	x	

Three courses of training are possible. The new employee may be given only the basic training included in the tack welding course, and sent out into the yard as a tack welding helper. Those who prove themselves apt during training may be given all the exercises and then be transferred to the welding department as arc welders. Again tack welding helpers may be returned to the school after a few months of experience, and brought to the arc welding level: 80 to 90 hours are needed to train a tack welder; 200 to 220 hours for the full welding course; and from 60 to 80 hours for the tack welder to complete the remaining exercises to become an arc welder. Each class should not include more than 20 students.

### Supervisory Training

In case of the rapid expansion of the working force in the yard, it would be necessary to promote many men to supervisory jobs. These workers are more or less experienced in production, but usually are totally inexperienced in the art of managing men. The "Foremen's Conferences" is commonly adapted in training supervisory force. In these conferences fundamental principles of worker psychology are established and amply illustrated by local incidents. Here it is easy to bring out a contrast between good and bad worker management.

In setting up these conference groups there are certain desirable features to be reached for. First, the conference room or rooms should not have the appearance of the formal class room. A large table around which the conferees can sit comfortably, with a convenient blackboard or perhaps wall space on which charts can be readily hung, is all that is required. Second, the group should not include more than twenty-five members, and these should present the widest possible range of yard departments to obtain catholicity of viewpoint. Third, the groups should be well mixed in years of supervisory experience, since the newly promoted supervisor has but little background on which to draw and must learn from the recital of experiences by his elders.

Fourth, a definite schedule of discussion topics should be worked out, and every participant should be encouraged to keep notes covering each meeting. Of course, the group leader must be thoroughly schooled to direct the sessions. The sessions are held in two evenings of each week. Discuss one topic for two hours in each session.

The next step is to provide and train leaders for these conferences. These men should be carefully chosen, and again should present a cross-section of the entire plant. The number of leaders for these conferences is according to the number of groups. Each leader should not handle more than four sessions a week.

The final step is to provide training for the group leaders in handling the discussions. Seventy hours will be required, and this should be scheduled during regular work hours somewhere in the plant. In this way confusion and interruption with production will be minimized. These leaders will come from many levels of supervision, foremen, quartermen, staff supervisors, instructors and others, and they can readily arrange for an hour or so of absence from work daily while their training is in progress. Additional sessions should be held nightly so that the leadership course may be completed in three weeks.

A typical list of topics for discussion is given below:

1. Supervisory duties and responsibilities
2. Giving orders
3. Carelessness
4. Maintaining discipline
5. Selecting and assigning jobs
6. Safety
7. Planning -- First discussion
8. Planning -- Second discussion -- supplementary:  
    (1) relations between departments, and (2)  
    passing along information
9. Training -- First discussion
10. Training -- Second discussion
11. Training understudies
12. Labor agreement -- supplementary: Rating of workers
13. Inspection
14. Leadership

To sum up, the sequence of steps necessary in establishing such a program is as follows:

1. Determine the number of supervisors to be trained
2. Determine the number of conference leaders needed
3. Arrange for training these leaders
4. Select and train leaders
5. Divide supervisors into groups of approximately twenty each, mixing experienced and prospective supervisors from different departments in each group



6. Arrange suitable meeting places
7. Notify conferees of assignments and get conferences underway (28 hours per group)

Cost Estimate

The cost estimate of shipyard construction is considered more difficult than anything else, especially in the recent days. To arrive even at an approximate figure for work of this type, the estimators must have enough data to begin with. They are usually obtainable from the past record or from the dealers. The authors have tried their best to get the data from both shipyards and dealers but the result is very disappointing. On account of this, the authors have provided a short method of calculating the cost of the shipyard by treating things in groups, such as, certain things go to the building group, certain machinery goes to the fabricating shop, and so on. By figuring the price of an individual group, we can get a rough estimate of the total cost. Since the object of this thesis is merely to present the proposition of a shipyard for future construction, the present cost is not to be of great value.

As it is, however, subject to change from time, the method which we used is tabulated as follows:

<u>Cost of land</u>	367.3 acres @ \$500	\$183,650
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Buildings

## ONE STORY

Fabricating shop including the pipe shop	480,000 sq.ft.
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Machine shop, including electrical shop	240,000 sq.ft.
Boiler shop	144,200
Blacksmith shop	40,000
Turret shop	40,000
Sheet metal shop	20,000
Coppersmith shop	20,000
Foundry	60,000
Galvanizing shop	11,452
Paint and rigging shop	13,500
Powerhouse	15,200
Acetylene gas shop	3,600
Chipping school	2,500
Welding school	10,000
Cafeteria	15,000
Total area for one story buildings	1,075,452 sq.ft. @ \$500
Total cost of one story buildings	\$5,577,200

## SECOND FLOOR

Mold loft and superintendant's and foreman's office on the second floor of the fabricating shop	120,000 sq.ft.
Second floor in machine shop	70,000
Total area in second floor	190,000 sq.ft. @ \$3.50
Total cost of second floor	\$ 665,000

## TWO STORY BUILDINGS

Main building	60,000 sq.ft.
Joiner shop, pattern shop, carpenter shop	100,000
Storehouse	50,000
Hospital	7,000
Apprentice school	15,000
Total area of two story buildings	232,000 sq.ft. @ \$6.00
Total cost of two story buildings	\$1,392,000
Miscellaneous buildings	\$ 400,000
Total cost of buildings	\$8,034,260

## SEA WALL

About 5000 feet @ \$150 \$ 750,000

## 5 PIERS

1000' x 80' - 80,000 sq.ft. @ \$2.00 \$ 160,000

Dredging

5000 x 2000 x 27 - 10,000,000 cu. yds @ \$.10 foreshore and approach	\$1,000,000
Railroad 10 miles at \$20,000 per mile (including tracks on piers)	\$ 200,000
Crane tracks about 4 miles at \$50,000	\$ 200,000
Water heating, sewers, electric mains air mains, paving, telephone, etc.	\$ 800,000
Miscellaneous, including some possible additional dredging and unforeseen con- turgencies	\$ 200,000

Total cost of dredging including railroad track, crane track, etc.	\$3,310,000
---	-------------

## CRANE

23 Gantry cranes each \$30,000	\$ 690,000
41 Bridge cranes each \$35,000	1,435,000
4 Locomotive cranes each \$20,000	40,000
9 Mobile cranes each \$15,000	135,000
Total cost of cranes	\$2,300,000

## COST OF MACHINERY AND EQUIPMENT IN SHOPS

Fabricating shop (including pipe shop)	\$4,000,000
Mold loft	300,000
Machine shop (including electrical shop)	5,000,000
Boiler shop	1,500,000
Blacksmith shop	800,000
Turret shop	200,000
Sheet metal shop	200,000
Coppersmith shop	60,000
Foundry shop	150,000
Galvanizing shop	50,000
Paint and rigging	20,000
Acetylene gas shop	20,000
Powerhouse	200,000
Miscellaneous shops	300,000
Total cost of machinery	\$12,800,000

TWO SHIPWAYS	\$ 650,000
SIX SHIPBUILDING BASINS each \$100,000	600,000
2000 TONS FLOATING DRY DOCK (compare with San Diego \$369,892)	500,000
TWO MARINE RAILWAYS	350,000
Total cost of shipways, marine railways and shipbuilding basins	\$2,100,000
Total cost of the proposed shipyard	\$28,727,810

It will be noted that the graving dry dock has been omitted in this shipyard estimate. It will cost \$5,000,000 or more in comparison with the graving dry dock of the Boston Navy Yard.

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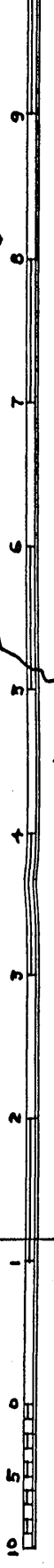
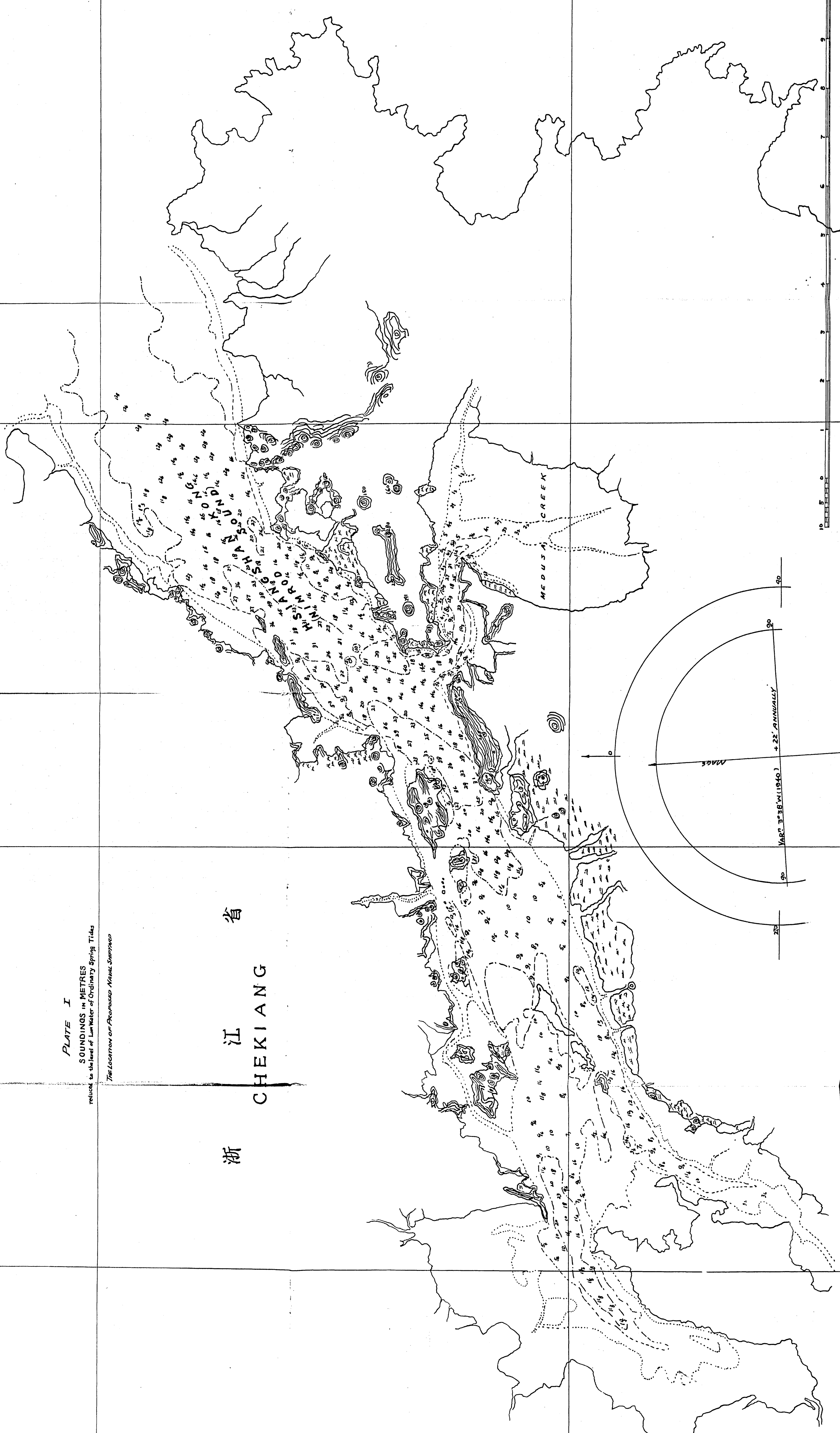
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PLATE I

SOUNDINGS IN METRES  
reduced to the level of Low Water of Ordinary Spring Tides

The Location of Proposed Natural Shipyard

浙 江 省  
CHEKIANG



LONGITUDE EAST FROM GREENWICH

40°

30°

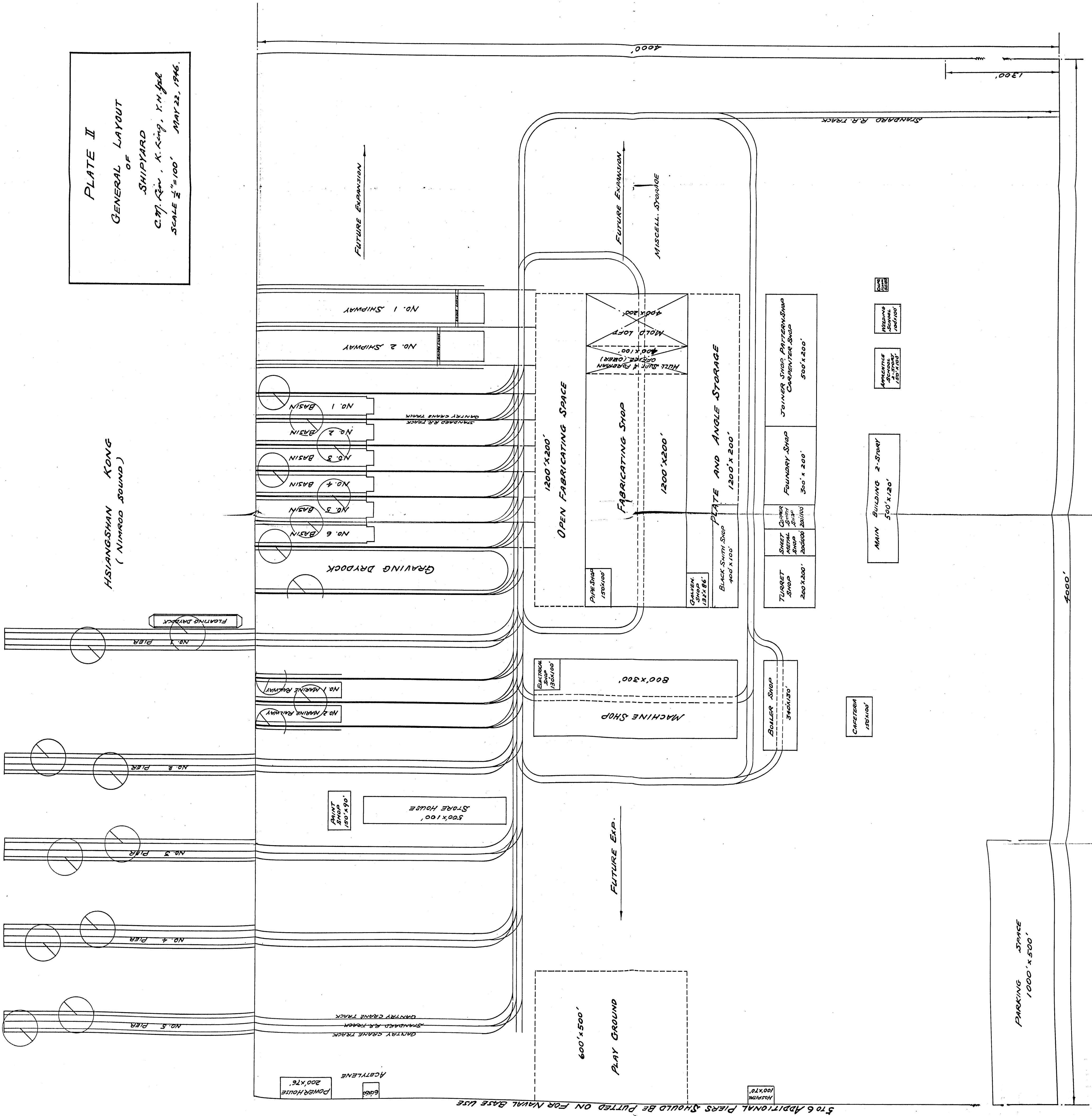
# PLATE II

GENERAL LAYOUT  
OF

SHIPYARD

C. M. Qin, K. Ling, Y. H. Jell  
SCALE 1/8" = 100' MAY 22, 1946.

HSIANGSHAN KONG  
(NIMROD SOUND)



5 to 6 Additional Piers Should Be Put On For Naval Base Use

PARKING SPACE  
1000' x 500'

4000'

1300'

STANDARD R.R. TRACK

FUTURE EXPANSION

MISCELL. STORAGE

OPEN FABRICATING SPACE  
1200' x 200'

FABRICATING SHOP  
1200' x 200'

PLATE AND ANGLE STORAGE  
1200' x 200'

BLACK SMITH SHOP  
400' x 100'

GALV. SHOP  
150' x 100'

PIPE SHOP  
150' x 100'

MACHINE SHOP  
800' x 300'

ELECTRICAL SHOP  
150' x 100'

BOILER SHOP  
300' x 150'

CAFETERIA  
150' x 100'

MAIN BUILDING 2-STORY  
500' x 120'

APPRENTICE SCHOOL  
150' x 100'

WELDING SCHOOL  
150' x 100'

SHIPYARD

PAINT SHOP  
150' x 100'

STORE HOUSE  
500' x 100'

POWER HOUSE  
200' x 76'

ACETYLENE  
6000'

STANDARD R.R. TRACK

GANTRY CRANE TRACK

No. 5 PIER

No. 4 PIER

No. 3 PIER

No. 2 PIER

No. 1 PIER

FLOATING DRYDOCK

No. 6 BASIN

No. 5 BASIN

No. 4 BASIN

No. 3 BASIN

No. 2 BASIN

No. 1 BASIN

STANDARD R.R. TRACK

GANTRY CRANE TRACK

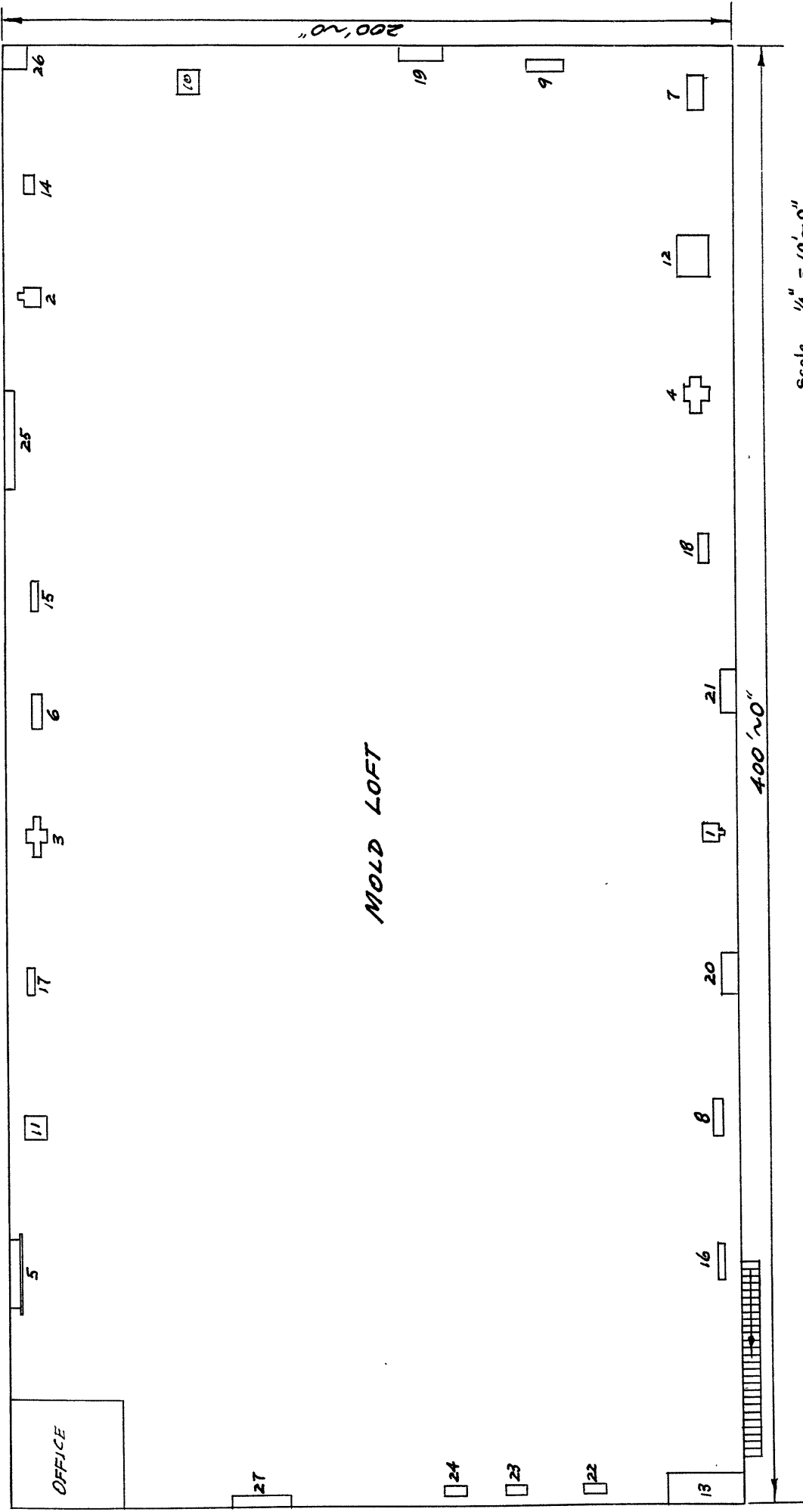
No. 2 SHIPWAY

No. 1 SHIPWAY

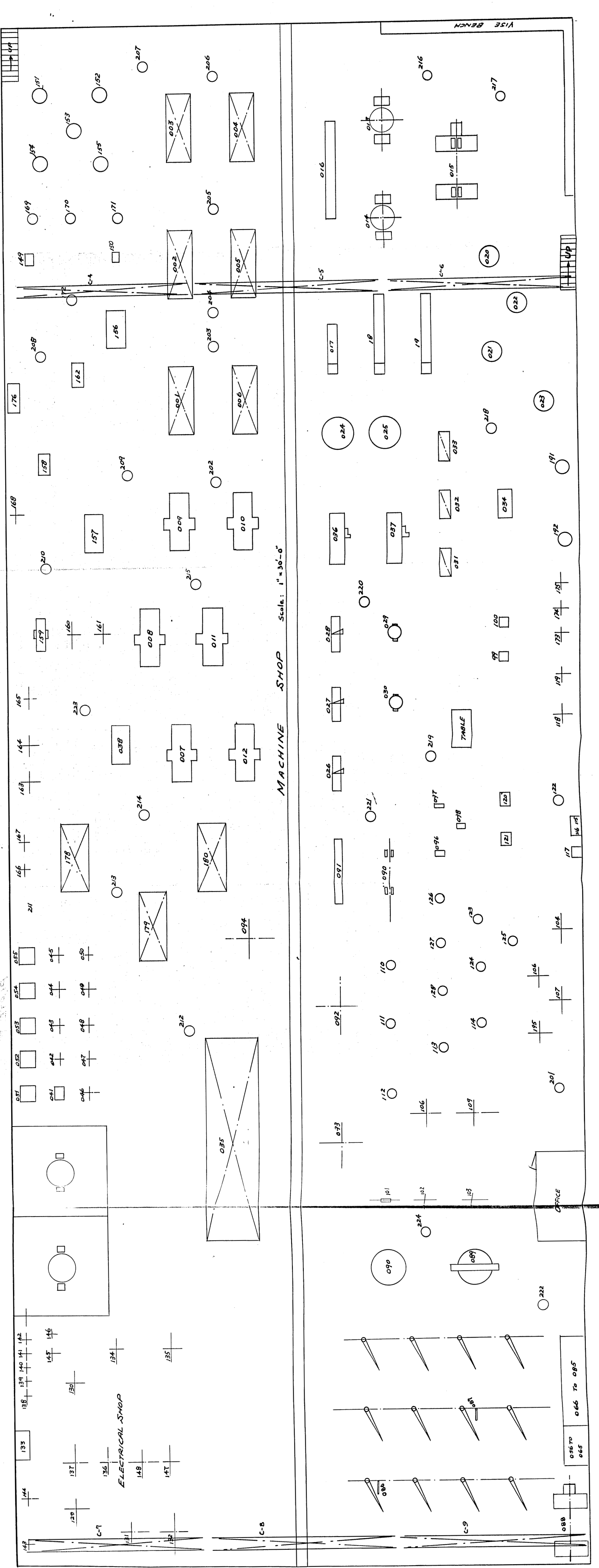
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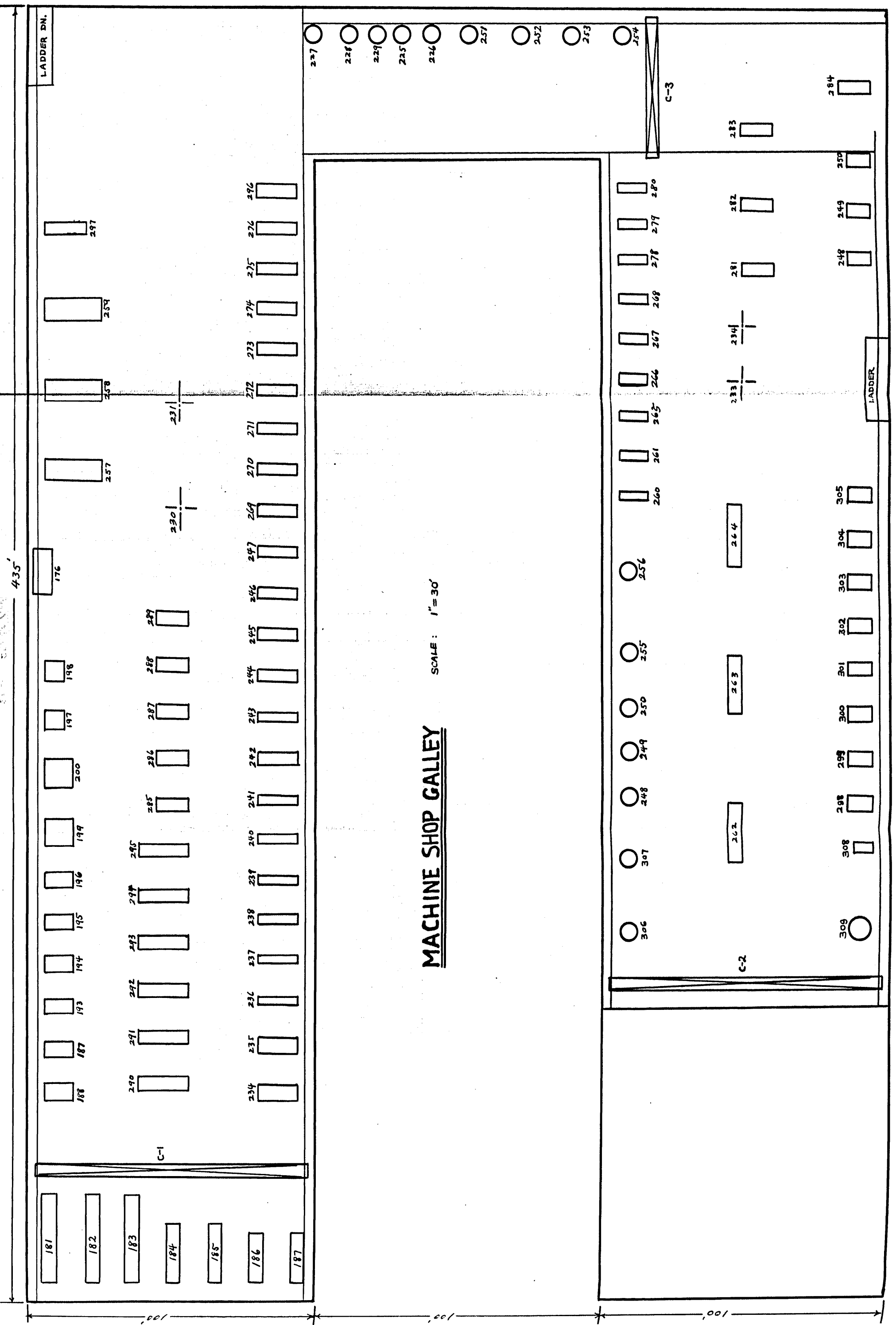


PLATE II



Scale  $\frac{1}{4}" = 10' \sim 0"$

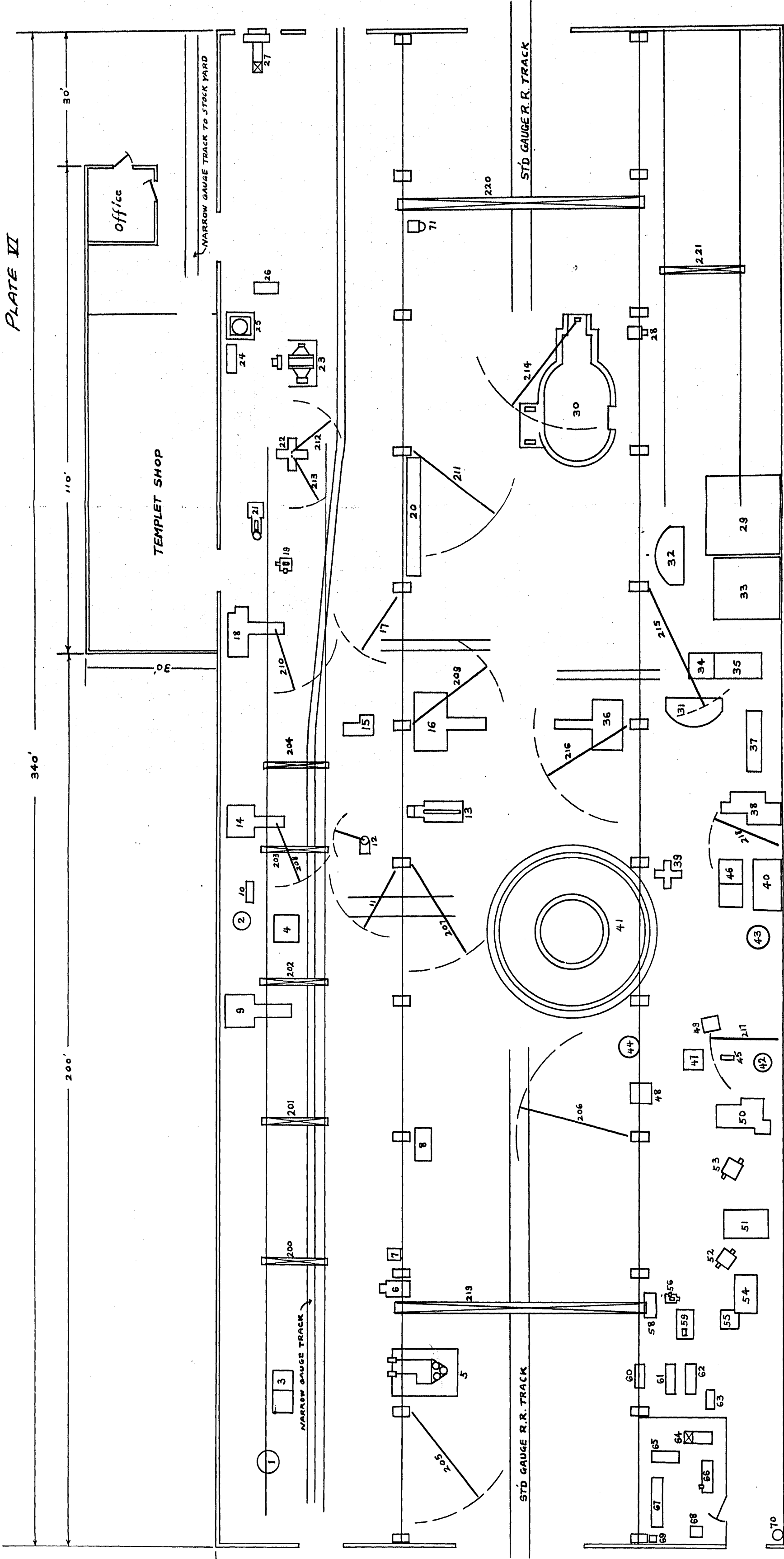




MACHINE SHOP GALLEY

SCALE: 1" = 30'





SCALE: 1"=20'

BOILER SHOP

# BLACKSMITH SHOP

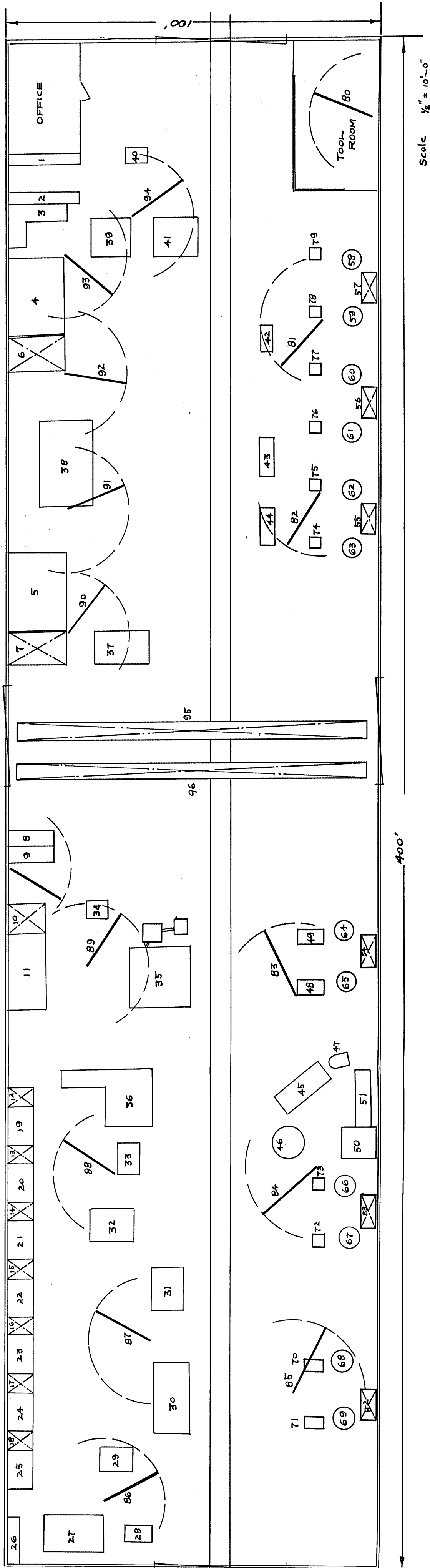
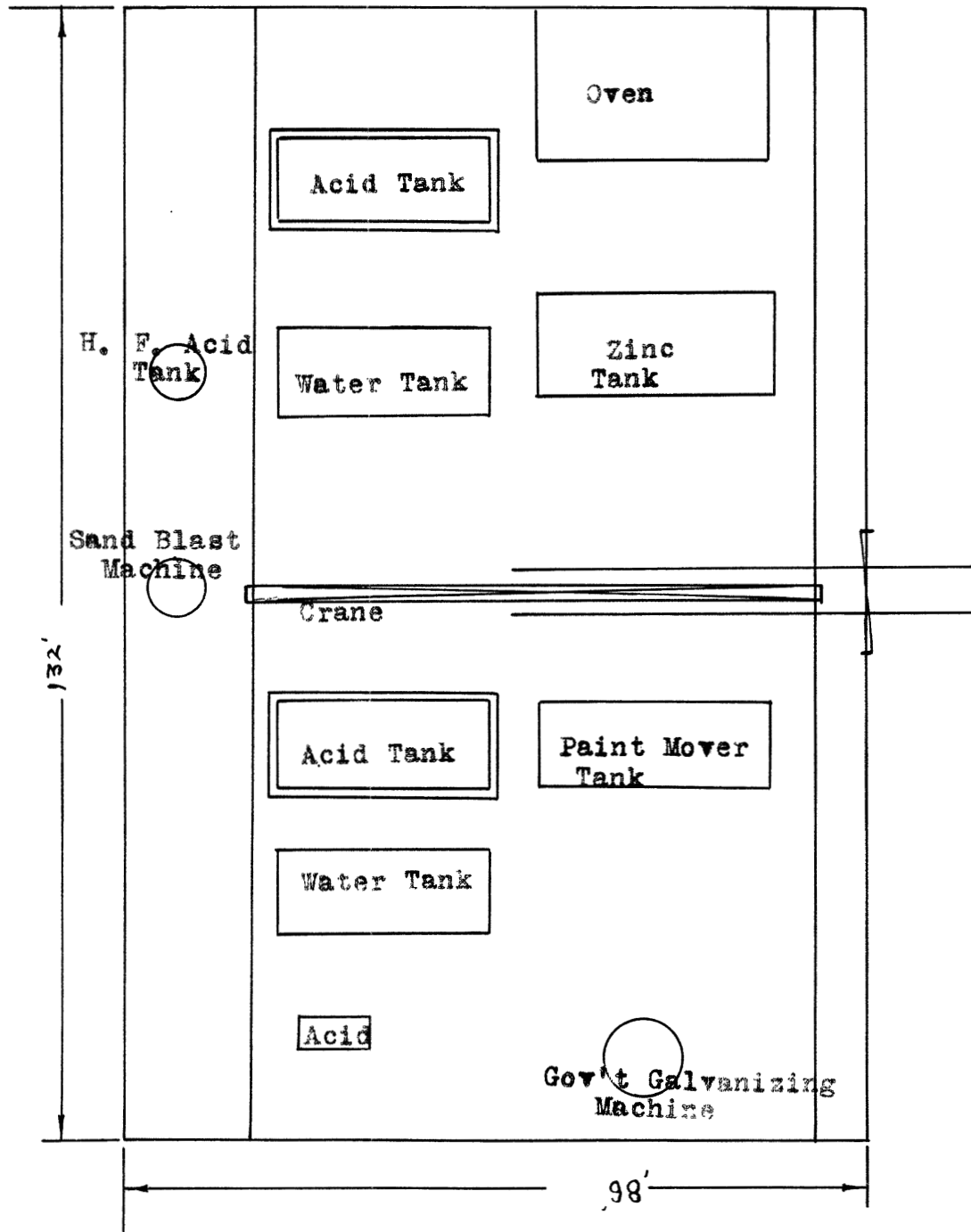
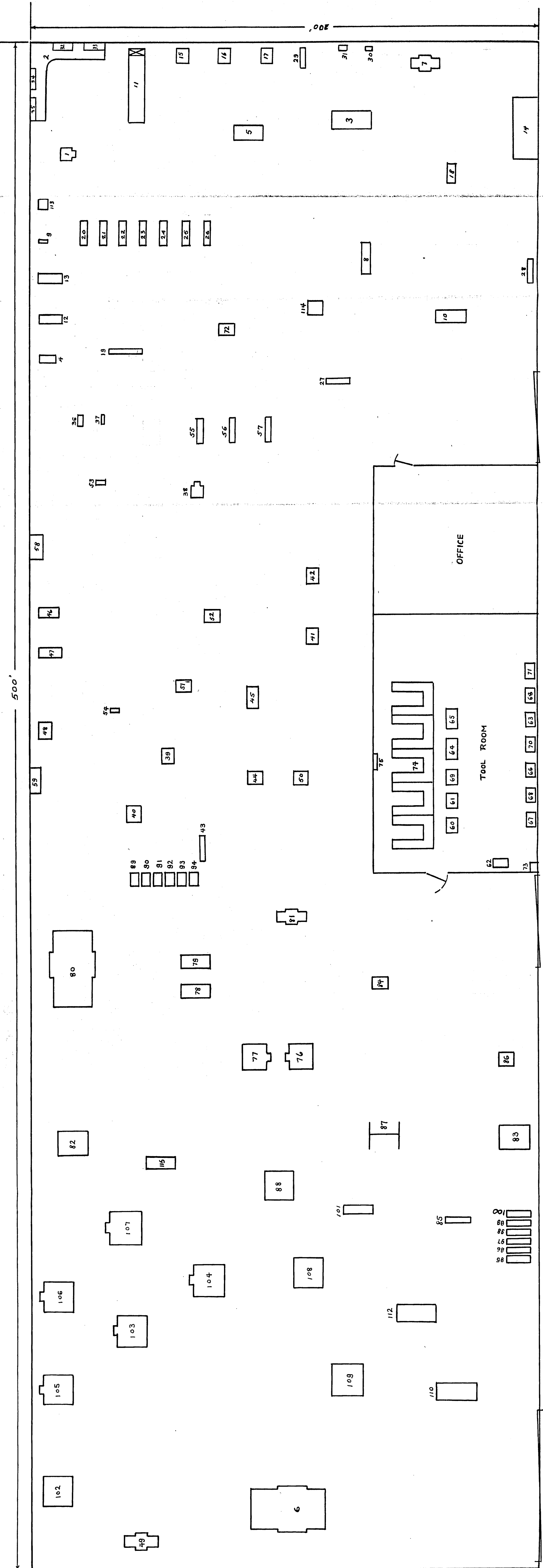


PLATE VIII

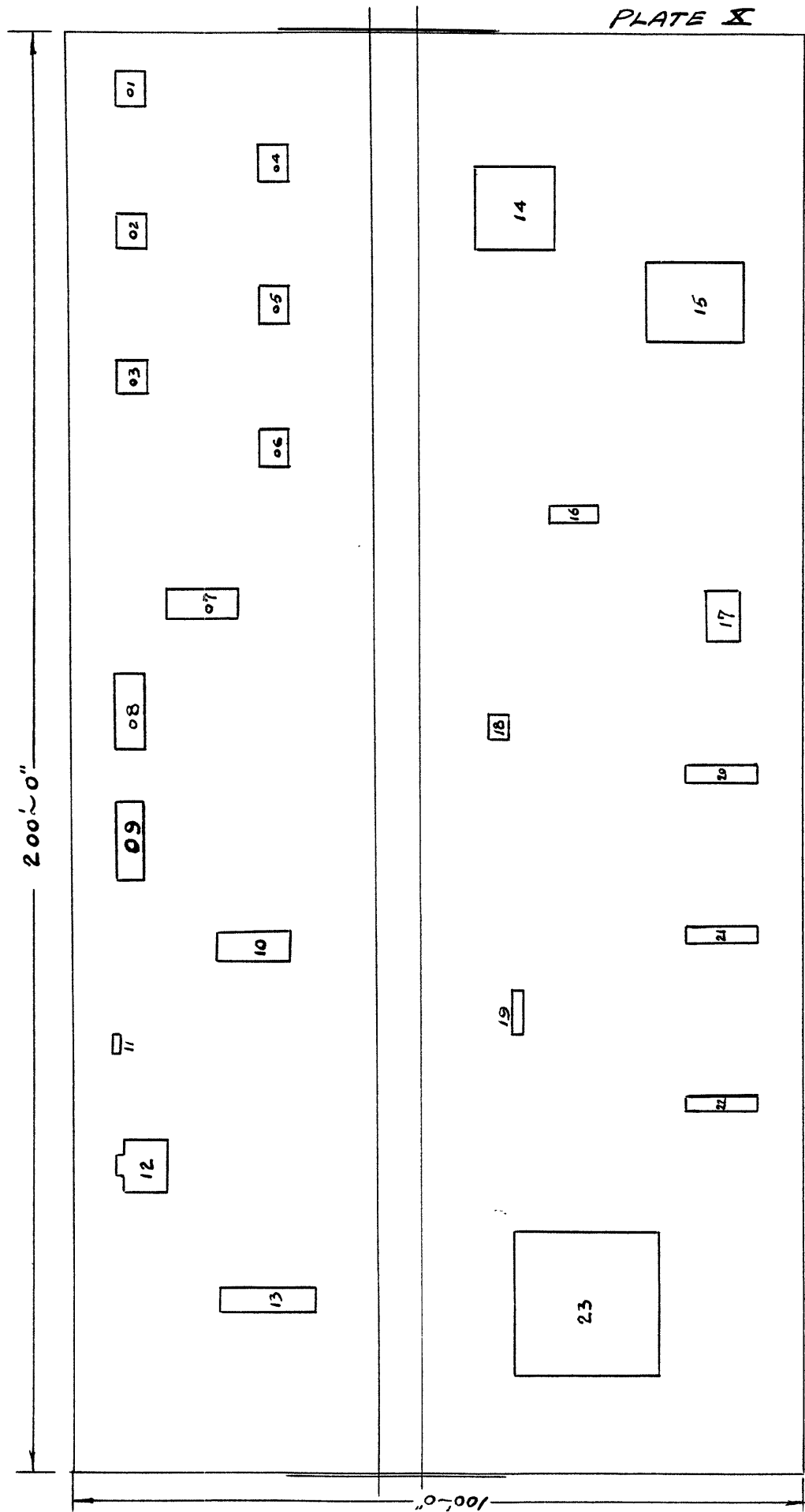


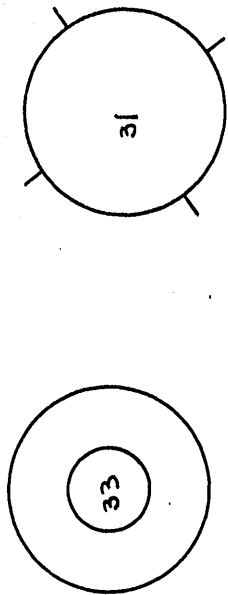
Galvanizing Shop

Scale  $\frac{1}{2}" = 10'-0"$

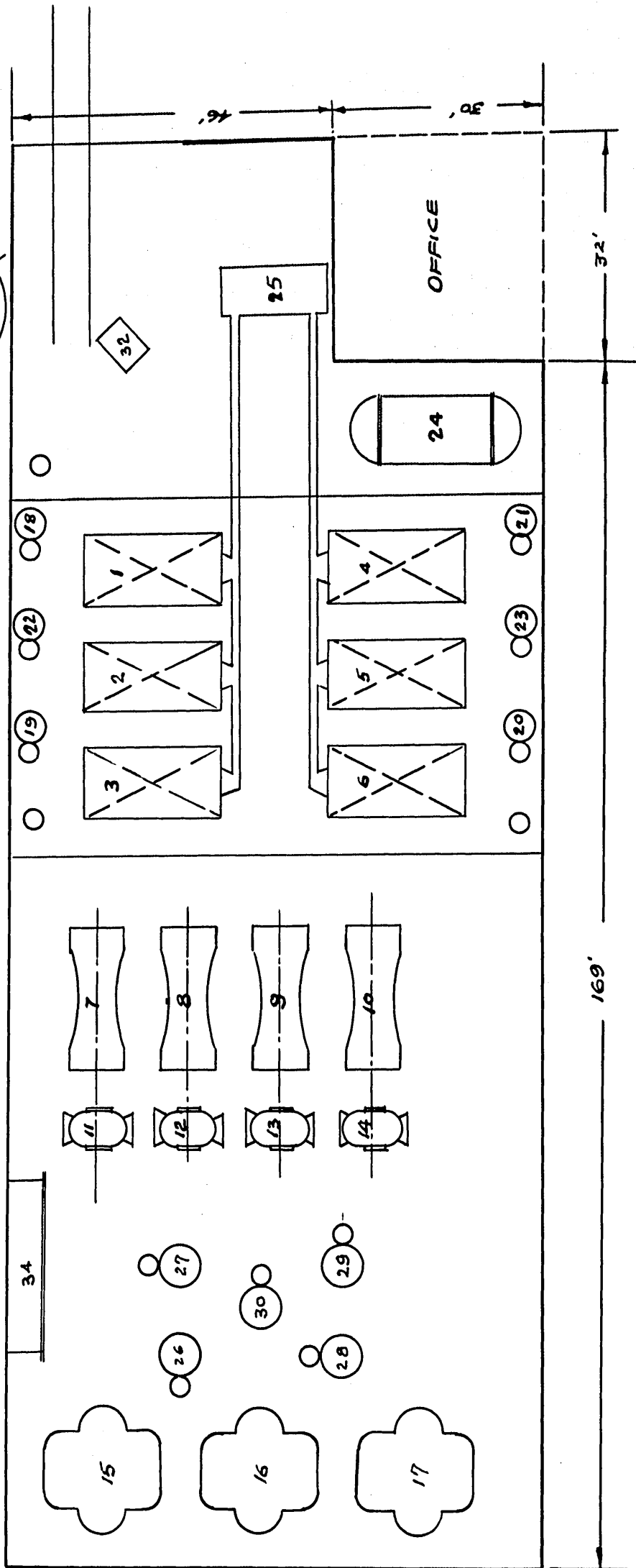


WOOD WORK SHOP SCALE: 1"=20'





POWER HOUSE



Scale 1/2" = 10'-0"